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# USSR Report

ELECTRONICS AND ELECTRICAL ENGINEERING

No. 93

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USSR REPORT  
ELECTRONICS AND ELECTRICAL ENGINEERING

No. 93

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METHODS OF SIGNAL PROCESSING IN SYNTHETIC-APERTURE RADAR FOR SOLUTION OF NATIONAL ECONOMIC PROBLEMS (REVIEW)

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 16 Sep 80) pp 193-213

SHTEYNShLEYGER, V. B., YERKIN, A. N., LIFANOV, P. S., MISEZHNIKOV, G. S.  
and YANOVICH, A. V.

[Abstract] Basic operating principles of synthetic-aperture high-resolution radar are summarized, assuming a transmitter signal with periodic pulse modulation and an echo signal converted by the phase detector in the receiver to one with linear frequency modulation. Such radar is becoming increasingly useful in exploration of the earth crust and the seabed from spacecraft, in search of natural resources and for monitoring of the environment. The capabilities of such radar were first realized through optical processing of signals in real time. Improvements in this method include the use of a telescope and a Pockels Readout Optical Modulator. Recording of primary data is still a problem, the disadvantage of photographic film being the time delay caused by the finite duration of photochemical processes. The disadvantages of variable-thickness thermoplastic films are low sensitivity, criticality of development by heating, and narrow dynamic range. A better method of signal processing is with cathode-ray memory tubes ("lithocon" with silicon target and  $\text{SiO}_2$  coating), preferably frame-by-frame rather than quasi-continuous mode because of less stringent requirements on the CRO performance characteristics and on the width of the signal spectrum. This analog device cannot deliver the necessary precision at high focusing ratios. The best method so far is digital or discrete-analog signal processing, preferably with elimination of redundancy and a low readout repetition rate. Most efficient here is partial data compression, for which several algorithms are available: time scale conversion, frame-by-frame processing, and filtration of Doppler frequencies. Figures 9; references 34: 18 Russian, 16 Western.  
[199-2415]

## ANTENNAS & PROPAGATION

### ADM-2.5 HIGH PERFORMANCE RADIO RELAY ANTENNAS

Moscow VESTNIK SVYAZI in Russian No 11, Nov 81 p 49

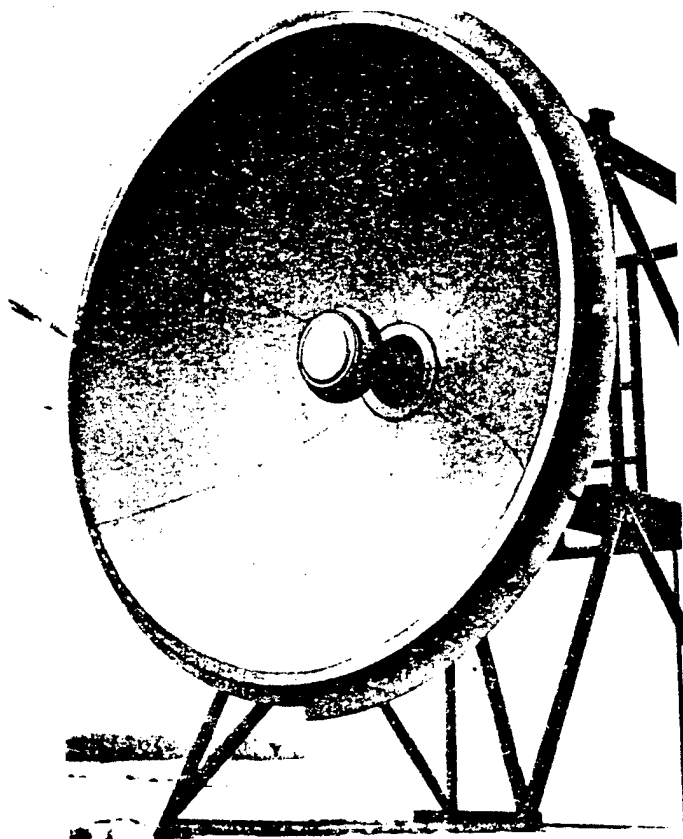
[Article by Yu. A. Yerukhimovich, candidate of technical sciences, senior scientific worker at NIIR: "Set of radio relay antennas"]

[Text] The AMD-2.5 antenna belongs to a series of high performance axial symmetric twin reflector antennas for radio relay communications which have been developed by a collective of workers at the USSR Ministry of Communications State Scientific Research by Institute of Radio. These antennas are now in series production. The antennas in this series have radiating aperture diameters of from 1 to 5 m and are designated, respectively, as follows: ADE-1; AMD-1.75; AMD-2.5; ADE-3.5; ADE-5. All of these antennas are based on a new plan with a displaced focal axis of the parabolic generatrix. A number of USSR patents are used in their construction (for example, No 237 934, 316 357, 280 574, 645 484, et al.), which made it possible to provide good electrical parameters and design characteristics.

A number of new technological processes and materials are used in producing the antennas: electroforming of thin layers of metal followed by strengthening with plastic foam; a radio transparent system used to fasten the secondary reflector on the horn, which also seals the feeder; pressure casting; ordinary and metallized fiberglass, etc. Under ordinary conditions, the antennas do not require external protection by randomes or covers. The removable protective enclosure is provided for especially difficult climatic zones.

The operating ranges of the antennas cover the entire span of frequencies used for radio relay communications — from 2 to 12 GHz. The antennas have a high coefficient of surface utilization —  $K_{su} \leq 0.7$ ,  $SWR \leq 1.06$ , protective action of at least -65 dB, and lowest level of cross-polarization field at least -30 dB.

The directivity patterns satisfy the specifications of the SSIR reference patterns for high performance antennas. Operation is possible on two respectively perpendicular linear or two rotating field polarizations and in two adjacent radio frequency bands simultaneously. The AMD-2.5 antenna (cf. figure) is designed primarily to operate in the "Oblast" communications system in the 8 GHz range.



AMD-2.5 radio relay antenna.

Of all other types of antennas with displaced focal axis of the ADE and AMD type, these have, for the same gain, the smallest size and weight, greatest adaptability to manufacture and production economy, as well as good operating characteristics.

The AMD-2.5 and ADE-5 antennas have been given the State quality seal. The external appearance of the antenna is protected by industrial patents No 7115 and 10681.

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## SCATTERING OF ELECTROMAGNETIC WAVE IN SLOT IN DIELECTRIC LAYER ON IDEALLY CONDUCTING SURFACE

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 20 Jul 81) pp 66-70

VASIL'YEV, Ye. N. and FEDORENKO, A. I.

[Abstract] Individual wafers cemented to an ideally conducting substrate are often used as absorbing coverings. Gaps inevitably appear between these wafers and they act as scattering centers. A model problem is discussed for the purpose of studying the diffraction characteristics of scattering centers of this type. In a layer of dielectric of given thickness there is a slot which is filled with a dielectric with specific electrical and magnetic parameters. It is assumed that the structure is symmetric relative to the  $x = 0$  plane and that the shape of the edge of the slot and of the filling are arbitrary. A plane electromagnetic wave with E- or H-polarization strikes at a specific angle to the X axis perpendicular to the direction of the slot. The problem is to find the scattered field. By means of a mirror transformation the problem is reduced to the problem of the diffraction of two waves in a layer of doubled thickness. A system of integral equations is derived for the equivalent electric and magnetic current densities determined at specific surfaces. It is demonstrated that with a low coefficient of reflection from the dielectric layer the secondary field is determined basically by reflection from the uncovered portion of the substrate and its level is comparable with the level of the scattering field in an ideally conducting strip of the same width as the slot, at least in the sector of angles far from grazing angles. It is shown that with  $\Delta < \lambda/2$ , where  $\Delta$  is the size of the slot and  $\lambda$  is the wavelength, the level of the scattered field is lower with E-polarization than with H-polarization and that this difference becomes smaller with an increase in  $\Delta$ . The addition of a filling has a substantial influence on the change in the slot's effective scattering surfaces if the density of the dielectric from which the filling is made is considerably greater than the density of the dielectric layer. The calculation results presented make it possible to evaluate the scattering properties of the structure studied with various dimensions of the slot and various parameters of the dielectric layer. Figures 3; references 3: 2 Russian, 1 Western. [218-8831]

## PERTURBATION OF IONOSPHERIC F-LAYER BY INTENSE RADIO WAVE

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 24 Mar 81) pp 127-132

KOLESNIK, A. G., Siberian Physico-Technical Institute at Tomsk University

[Abstract] The behavior of the ionospheric F-layer in the temperate zone upon heating by an intense radio wave is analyzed on the basis of the mathematical model of transients in an ionospheric plasma. The corresponding equations describe the dynamics of and the energy relations in three plasma components: charged ( $\text{NO}^+$ ), neutral ( $\text{N}_2, \text{O}_2$ ) and metastable. These equations have been solved by the method of finite differences with matrix elimination and Newton iteration, for appropriate heliogeophysical conditions typical of the temperate zone. The thus calculated transients of  $\text{NO}^+$  concentration and electron concentration as well as of vibrational temperature and electron temperature reveal the trend of buildup after turn-on and then complete relaxation to ambient levels after turn-off of the pumping radio wave. The relaxation of electron concentration in the F-layer is sufficiently slow to let the F-layer "memorize" the event. The author thanks M. N. Vlasov for helpful and stimulating discussions. Figures 2; references 14: 7 Russian, 7 Western.  
[201-2415]

## EXTRACTION OF RADIO WAVES FROM IONOSPHERIC WAVEGUIDES BY MECHANISM OF BEAM SWINGING

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 13 Nov 80, after revision 14 May 81)  
pp 133-139

AFANAS'YEV, N. T., SVISTUNOV, K. V. and TININ, M. V., Irkutsk State University

[Abstract] The mechanism of energy extraction from ionospheric waveguides, particularly between E and F layers, through various large-scale inhomogeneities along the path of propagating decameter radio waves is analyzed on the basis of a resonance model. Resonant swinging of radio beams is described approximately by a second-degree two-dimensional differential equation in Cartesian coordinates with appropriate initial and boundary conditions. A solution of this equation, by the method of averaging or by the method used for solving the similar Mathieu equation, yields the amplitude of the swinging trajectory and the conditions of parametric resonance. Analytical results compare fairly accurately with results of numerical solution for 1000 and 2000 km long distance assuming various initial beam "phases." Figures 2; references: 12 Russian.  
[201-2415]

## RESULTS OF ANNUAL-CYCLE MEASUREMENTS OF VERTICAL ATTENUATION AT 8.2 mm WAVELENGTH IN TERRESTRIAL ATMOSPHERE BASED ON INTRINSIC RADIATION

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 13 Mar 80) pp 214-219

BABKIN, Yu. S., SUKHONIN, Ye. V. and CHERNYSHEV, V. I.

[Abstract] Measurements based on intrinsic atmospheric radiation in the central European part of the Soviet Union have yielded annual and seasonal statistical distributions of total vertical attenuation, at the 8.2 mm wavelength, caused by hydrometeorological formations in that region. Measurements were made by the radiometric method in the Zimenki village (Gor'kovskaya oblast) for 5500 h during the period from 4 July 1978 to 4 July 1979. The equipment included an h-f stage in the focal module of an RT-25x2 radio telescope, with a horn antenna having a  $54 \times 540 \text{ mm}^2$  rectangular cross section and located at a distance of 6 m from a rotatable  $2 \times 2 \text{ m}^2$  plane metallic reflector of sky radiation. The superheterodyne-type radiometer with modulation was capable of measuring a noise signal in the 400 MHz band along both i-f main and reflector channels. The data on vertical attenuation by stratus and cumulus clouds as well as by rain drops of all except very small sizes have been processed and can be further processed, by application of the law of cosines, to yield statistics on oblique attenuation in "ground - satellite (geostationary)" communication lines. The data reveal a maximum attenuation of up to 25 dB in summer and a minimum attenuation up to 2 dB in winter. The authors thank A. G. Kislyak, M. A. Kolosov and A. V. Sokolov for steady interest and helpful comments. Figures 3; references 17: 6 Russian, 11 Western.  
[199-2415]

## PROPAGATION OF SHORT RADIO WAVES THROUGH MAGNETOSPHERIC CHANNELS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 25, No 2, Feb 82 (manuscript received 10 Jun 81) pp 140-143

YERUKHIMOV, L. M., KROTOVA, Z. N. and URYADOV, V. P., Scientific Research Institute of Radiophysics

[Abstract] Transequatorial propagation of short and ultrashort radio waves through "ducts" between oblong inhomogeneities in the geomagnetic field is analyzed on the basis of the wave equation in MacIlvain coordinates. A computer-aided numerical solution indicates the feasibility of channeling decameter and meter waves between geomagnetic latitudes not farther than  $30^\circ$ , if the transverse gradient of electron concentration is moderate. The results also yield the relation between "duct" parameters and the passband. Figures 2; references 13: 7 Russian, 6 Western.  
[201-2415]



## COMPENSATION OF PHASE DISTORTIONS IN SPACED APERTURES BY MEANS OF BROADBAND SIGNAL

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 2 Feb 81) pp 293-303

ZHULINA, Yu. V.

[Abstract] The problem of observing K bright objects in space by means of N transmitters and M receivers is considered when each transmitter probes an object independently. An algorithm of simultaneous estimation of coordinates as well as amplitudes and phase distortions is constructed according to the maximum-likelihood principle and with use of a broadband probing signal having a resolution interval smaller than the distance between individual objects. Phase distortions are assumed to occur only in the atmosphere and in the equipment. The reflecting surfaces of objects are assumed to be completely independent and unknown, determined by their diffraction patterns. The error of measurements is evaluated by averaging the matrix of second derivatives of the logarithm of the likelihood function with respect to the measured parameters at their true values. The feasibility of accurate measurement of relative coordinates is established on the basis, even with phase distortions in the signal. The constraints are also established for accurate measurement, by the coherent method with phase compensation, of absolute coordinates. References: 2 Russian.  
[199-2415]

## CORRELATION CHARACTERISTICS OF OVERSHOOT FLUX INTENSITY IN ATMOSPHERIC RADIO INTERFERENCE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 16 Jan 81) pp 287-292

DOBRYAK, D. S. and PETROVA, L. G.

[Abstract] The characteristic functional of instantaneous overshoot flux intensity in atmospheric radio interference caused by a thunderstorm is obtained for the very-low-frequency range. After territorial distribution and variation in time have been considered, statistical relations are established between intensities at various instants of time at various levels of receiver threshold sensitivity. The correlation coefficient is calculated accordingly, as a function of the distance between receivers and as a function of the relative difference between mean intensities. The correlation time of an overshoot flux intensity is also calculated, as a function of the mean intensity. An overshoot flux is regarded as a random

field and these correlation characteristics render a rather complete statistical description of its intensity. Other characteristics of atmospheric radio interference such as its spectral density can be obtained analogously. Figures 4; references 4: 3 Russian, 1 Western. [199-2415]

UDC 621.391.193

MEASUREMENT OF FREQUENCY AND ANGLE OF ARRIVAL OF SIGNALS RECEIVED BY ANTENNA ARRAY AGAINST BACKGROUND OF NOISE IN ACOUSTO-OPTOELECTRONIC PROCESSING

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 25, No 2, Feb 82 (manuscript received 6 Jun 80, after completion 13 Nov 80) pp 21-28

NAKHMANSO, G. S.

[Abstract] Acousto-optoelectronic processors represent multichannel ultrasonic light modulators combined with optoelectronic systems making it possible to process the signals of antenna arrays in real time. A discussion is presented of the accuracy of measuring the angle of arrival and frequency of narrowband signals received by a linear antenna array against a background of external noise and the intrinsic noise of the optoelectronic system, taking into account the nonidentity of the amplitude-phase characteristics of the input channels of the acousto-optoelectronic processor (AOEP). The formula is given for the vector of the received signals when the receiving antenna is represented as a linear equidistant array with  $2N + 1$  receiving elements arranged at a distance of  $b$  from one another. Electrical signals from the receiving elements of the antenna enter input channels and the input of a  $(2N + 1)$ -channel ultrasonic light modulator. The electrical signals act on piezoelectric transducers and excite acoustic signals, which, being propagated in the acousto-optic interaction medium of the working channels of the ultrasonic light modulator at a certain speed, cause a change in the refraction coefficient of the medium according to a specific rule. An equation is presented for the distribution of the intensity of the light field in the outlet focal plane of the integrating lens as a function of spatial frequencies,  $I(u, \theta, t)$ , and equations are presented for the statistical characteristics of  $I(u, \theta, t)$ , its mean value and the correlation function. The electrical signal from the output of a photodetector enters the input of the electronic circuit of the optoelectronic system, which contains in each channel linear amplifiers and threshold devices whose output signals enter the input of a resolver. The resolver makes an estimate of the frequency and angle of arrival of the signal being analyzed. The statistical characteristics are given for estimates formed, of the frequency and angle of arrival of a signal. These statistical characteristics are determined by the power level of the external noise and intrinsic noise of the optoelectronic system. Worsening of these characteristics is

dependent on the choice of the threshold level at which measurements are made and on the degree of the difference in the amplitude-phase characteristics of the AOEP's input channels. Preamplifiers for the AOEP's input channels must be chosen which have low noise characteristics and identical amplitude-phase characteristics. Figures 4; references: 6 Russian, [218-8831]

UDC 621.391.264.6

#### INFORMATION CAPACITY OF MULTICHANNEL ACOUSTOOPTIC MODULATORS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 25, No 2, Feb 82  
(manuscript received 23 Jul 80, after revision 9 Feb 81) pp 94-97

BANNOV, V. Ya., GUSEV, V. A. and KIPPER, R. I.

[Abstract] The information capacity of multichannel acoustooptic modulator (MAOM's) is the number of resolvable light spots formed by the optical system in the output plane. The number of resolvable light spots for the X coordinate equals the number of channels and depends on the height of the acoustooptic conductor, the width of the electrodes of the piezoelectric transducer and the gap between these electrodes. The number of resolvable light spots for the Y coordinate is determined by the width of the transmission band of each channel and by the duration of the introduced signal, which is in turn expressed in terms of the aperture of the incident light and the velocity of the acoustic wave. Equations are presented which express these relationships and on their basis and on the basis of further analysis of the terms contained in them a final formula is presented for determining the information capacity of MAOM's, which also takes into account the relationship between the central frequency, diffraction efficiency and the width of the transmission band. Included in this formula is the acoustooptic figure of merit for the MAOM's material. On the basis of the formula for determining information capacity, a comparison is made of various acoustooptic materials arranged in order of an increase in the attenuation factor,  $\alpha_0$ , which determines the attenuation of the power of the acoustic wave at the end of the acoustooptic conductor. It is demonstrated that the information capacity of an MAOM is determined to a considerable extent by the acoustooptic figure of merit of the material of the acoustooptic conductor and in addition by the height of this conductor, which determines the number of channels. The various materials studied are divided in terms of operating frequencies into three groups. With a permissible amount of attenuation of the acoustic wave at the upper frequency of the band equal to 2 dB/cm, materials with an attenuation factor of  $\alpha_0 \geq 200$  dB/GHz<sup>2</sup>·cm can be used at frequencies to 100 MHz, with  $\alpha_0 \geq 8$  dB/GHz<sup>2</sup>·cm at frequencies up to 500 MHz and with  $\alpha_0 \geq 2$  dB/GHz<sup>2</sup>·cm at frequencies to 1 GHz. A promising material for MAOM's for frequencies up to 600 MHz is single crystals of gallium phosphide and for frequencies up to 900 MHz, Bi<sub>12</sub>GeO<sub>20</sub>. As<sub>2</sub>S<sub>3</sub> is promising for use at low frequencies.

The uniqueness of this study is that the results are based on taking into account the dependence of the MAOM's information capacity on the acousto-optic figure of merit of the acoustooptic conductor's material, diffraction efficiency and the power of the acoustic wave. Materials used in the same frequency band can be compared with respect to information capacity because the acoustic attenuation factor is used as the ranking parameter, and not the information capacity. Figures 2; tables 1; references 9: 6 Russian, 3 Western (1 in translation).  
[218-8831]

UDC 621.396.67

#### ELECTRODYNAMIC ANALYSIS OF LOG-PERIODIC LOOP ANTENNAS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 13 Mar 81) pp 86-89

YATSKEVICH, V. A. and RUBAN, A. P.

[Abstract] An electrodynamic analysis is presented of a log-periodic loop antenna designed as a coaxial system of loops with each loop having two pairs of terminals situated on opposite sides of the loop, whereby one pair of terminals is connected to one distributing line and the other to another distributing line and both distributing lines are connected in parallel to a common excitation source. The round loops are arranged on the surface of a cone and form a log-periodic structure. This antenna radiates a linear polarization field and the electric field vector is oriented parallel to the magnetic plane of symmetry of the system. The solution to the problem of the excitation of a thin ring conductor is generalized for the case of a coaxial system of circular loops. Expressions are presented for drawing the directivity diagram and for computing the directive gain. The procedure for making an electrodynamic analysis is outlined. Calculations have demonstrated that there is a well formed active region in antennas of this type which is similar to the active region of a log-periodic dipole antenna and which consists of loops whose perimeter is close to the wavelength. Current phasing makes possible directional radiation in the direction of the antenna's vertex. The operating band of a log-periodic loop antenna is fundamentally unrestricted and is determined by the ratio of the diameters of the largest and smallest loops. It is demonstrated that with identical overall dimensions of the antennas a log-periodic loop antenna has an operating band which is expanded approximately 1.5-fold into the low-frequency region as compared with the operating band of a log-periodic dipole antenna. However, a characteristic disadvantage of log-periodic loop antennas is their poor directional properties in the low-frequency region. The log-periodic loop antenna discussed is similar in characteristics and design to a frequency-independent helical radiator but differs from it in the linear nature of the polarization of the radiated field and has the advantage that there is a strict and efficient method of designing it which makes it possible to design and optimize it on a computer. Figures 2; references 6: 2 Russian, 4 Western (1 in translation).  
[218-8831]

## METHOD FOR CORRECTING DISTORTIONS OF RADIO BRIGHTNESS DISTRIBUTION CAUSED BY SIDE LOBES OF ANTENNA DIRECTIONAL PATTERN

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 14 Jul 80) pp 1654-1659

YEGOROV, S. T., PLYUSHCHEV, V. A. and VLASOV, A. A.

[Abstract] The authors propose a method of successive approximations [SA] for correcting amplitude distortions of radio brightness distribution which are caused by the side lobes of the antenna directional pattern. The following items are considered in the work: 1) Essence of SA method; 2) Convergence of SA procedure; 3) Digital realization of SA methods; and 4) Practical limitations superimposed on number of steps. It is shown that use of the SA method makes it possible in accordance with a measured distribution of the antenna temperature values, with a specified degree of precision, to restore the distribution of the values averaged with respect to the principal lobes of the radio brightness temperature. This can be obtained during a survey of the space of an "ideal" antenna with a directional diagram without side lobes. After each approximation the degree of the amplitude distortions resulting from side lobes can be reduced  $1-\beta/\beta$  times ( $\beta$  = scattering factor of antenna). The number of approximations necessary in each practical case depends on the width of the area of survey of the radiometer, the precision of measurement of the values of the antenna temperatures and the error of determining the directional diagram. Figures 1; tables 5; references: 6 Western.  
[88-6415]

## TWO-FREQUENCY COMBINED DIPOLE ANTENNA ARRAYS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 25, No 2, Feb 82 (manuscript received 24 Apr 81) pp 52-59

IL'INSKIY, A. S., PONOMAREV, L. I., BEREZHNYAYA, I. V. and DOLGIY, A. V.

[Abstract] Combined multifrequency dipole arrays represent a combination of single-frequency dipole arrays arranged one on top of the other in the same radiating aperture. Their purpose is to reduce the overall dimensions of an antenna operating at several frequency subbands. The characteristics of these arrays are distorted because of the mutual influence of one antenna on the other and at each frequency only one of the arrays in the combined array is excited and the others represent passive scatterers. Maximum distortions originate with identical polarization. The results are given of a study of the influence of a passive array for the second subband on the shape of the amplitude directional pattern, the level of side lobes and the

gain of the first-subband array in a two-frequency combined dipole array with matching linear polarization in both frequency subbands. The combined arrays are at a short distance from one another and have a finite number of dipoles with a total electric length of all dipoles at the higher frequency of not greater than 50 times the wavelength. With identical polarization the principal distortions are governed by current induced in the dipoles themselves. The electrodynamic model utilized for analysis is a system of parallel cylindrical thin-walled dipoles saturated in a certain cross section with concentrated e.m.f. of a certain frequency and each passive dipole at this frequency is assumed to be loaded by a random complex load in the cross section in which it is excited by concentrated e.m.f. at the other frequency. The problem reduces to solving a system of integral equations for the current in each actively and passively excited dipole in both frequency subbands and then in calculating from these currents the radiation field, directional pattern and input impedance of the actively excited dipoles at each frequency. It is shown that the upper dipole array exerts a shadowing effect resulting in lowering of the gain of the lower array, distortion of the directional pattern, the appearance of additional sidelobes, additional mismatching of its radiating elements and worsening of its accuracy characteristics. The level of distortion introduced depends primarily on the thickness of the dipoles of the upper array and on the ratio of the frequencies of the combined antenna arrays. The heaviest distortion in the directional pattern appears in the H-plane. The bottom array acts as an additional shield for the upper array and exerts an influence on its directional pattern and gain. Figures 9; tables 4; references:

4 Russian.

[218-8831]

UDC 621.396.677

#### INFLUENCE OF CORRUGATED STRUCTURES ON INTERACTION OF ANTENNA ARRAYS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 25, No 2, Feb 82

(manuscript received 9 Oct 80, after revision 21 Apr 81) pp 74-76

MARTSAFEY, V. V. and SHVAYKO, I. G.

[Abstract] The mutual interaction of pencil-beam antennas can be reduced by employing corrugated structures. A description and the results are given of a study of the influence of corrugated structures on the interaction of pencil-beam antenna arrays. The study is based on the results of the theory of the aperiodic excitation of an infinite packet of semi-infinite planar waveguides. This packet is divided into a transmitting antenna, receiving antenna and isolator. An analysis is made of the functioning of isolators of both the absorbing and purely reactive type. The elements of the receiving antenna are connected via matching elements and phase inverters to an ideal adder which makes it possible for the receiving array to operate

on a common load. It is assumed that the dimensions of the waveguides make possible the propagation of only waves of the T type, that the waveguides' walls are infinitely thin and ideally conducting, that the amplitudes of incident waves in the transmitting array are equal, that changes in phase in the elements of each array are possible, and that the time dependence is determined by the factor  $e^{-i\omega t}$ . The isolation is the parameter characterizing the degree of interaction of antennas and it is defined as the ratio of the radiated power to the power in the input of the receiver. Isolation is estimated for different variants of filling the space between antennas. These include placing semi-infinite waveguides between the antennas and placing between the antennas short-circuited waveguides simulating a corrugated isolating structure. In the latter case in the infinite packet of semi-infinite waveguides, waveguides situated between the antennas are short-circuited by means of plungers lowered to a certain depth. A determination is made of coupling coefficients in an aperiodically excited infinite packet of waveguides. It is demonstrated that coupling between antennas is maximum when the principal maxima of the factors of the transmitting and receiving arrays are oriented toward one another. Even relatively small reactive structures have a substantial influence on isolation. Isolation is increased by means of corrugated structures with a channel depth of  $0.22\lambda$  to  $0.5\lambda$ , where  $\lambda$  is the wavelength, for the antenna dimensions and distances between them discussed. The effectiveness of corrugated structures depends on the method of exciting the antennas, generally on the phase shifts in the antennas. A corrugated structure exerts an insignificant influence on the directivity pattern of aperture antennas. Figures 3; references: 6 Russian. [218-8831]

UDC 621.396.677.49:621.396.967.7

# FORMATION OF SPATIAL CHARACTERISTICS OF DIRECTIVITY OF NON-PLANE AXISYMMETRIC ANTENNA ARRAYS BY COHERENT OPTICS METHODS BY MEANS OF VOLUME HOLOGRAMS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 25, No 2, Feb 82  
(manuscript received 8 Sep 80, after revision 26 Jan 81) pp 29-34

GRINEV, A. Yu. and TEMCHENKO, V. S.

[Abstract] A description is given of the algorithm and structure of a coherent optical processor for processing the signals of radiating elements of antenna arrays arranged on a non-plane axisymmetric surface, by utilizing the selective properties of volume holograms. The surface is formed by winding a plane curve around some axis. Arrays of this type make possible a wide-angle coverage of space without reducing directional properties. An algorithm is presented which makes it possible to form the spatial characteristics of the directivity of non-plane axisymmetric antenna arrays with a random distribution of receiving elements. A description

is given of a coherent optical processor which implements this algorithm, whereby a particular addressing rule is established between the radiating elements of the non-plane axisymmetric antenna array and the channels of a space-time light modulator located in the subject plane and accomplishing the input of the array's signals into the coherent optical processor. The coherent optical processor performs a two-dimensional Fourier transform of the aperture response from each ring of the array by means of a spherical lens. A volume hologram in the form of a transparency is placed in the spectral plane so that the Fourier response received from each ring is multiplied by its "own" transparency, by utilizing the angular selectivity of a volume hologram. In the output plane of the coherent optical modulator light responses are formed in the form of the directional pattern of the antenna array and correspond to the radio emission sources found in the array's area of coverage. It is demonstrated that the coherent optical processor with a volume hologram transparency accomplishes the parallel formation of the spatial characteristics of the directivity of non-plane axisymmetric antenna arrays. Implementation of the processor is discussed in terms of the angular selectivity of the volume hologram, which depends on the distance between the channels of the space-time light modulator and the focal length of the converting lens. The condition is given for obtaining non-overlapping responses from adjacent rings of the antenna array. Figures 3; references 9: 7 Russian, 2 Western. [218-8831]

UDC 621.396.677.711

#### SLOT ANTENNA EMPLOYING TRAVELING WAVE RESONATOR

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian Vol 25, No 2, Feb 82

(manuscript received 29 Dec 80, after revision 20 May 81) pp 83-85

GOROBETS, N. N. and NESTERENKO, M. V.

[Abstract] A description and analysis are presented of a slot antenna employing a traveling wave resonator, which is created by turning a rectangular waveguide with longitudinal or transverse slots into a ring forming a traveling wave resonator which is excited by a coupling element. With directional coupling the resonance of waves propagated in a single direction originates in the ring and the antenna makes it possible to radiate with circular or elliptical polarization. With nondirectional coupling standing waves are formed in the traveling wave resonator and the radiated field has elliptical polarization close to linear. Resonance takes place upon the condition that a whole number of wavelengths is accommodated in the waveguide ring. A determination is made of the energy characteristics and directivity diagram of a slot antenna employing a traveling wave resonator with nondirectional coupling of the main waveguide with the ring, i.e., with a longitudinal slot. The complex amplitudes of voltages in all slots are found, uniquely determining the energy characteristics and the radiation



field of the antenna in the long-range region. The calculated directivity diagram is presented for one antenna of the type discussed and it is seen to be funnel-shaped. It is demonstrated that the presence of a resonator results in considerable narrowing of the frequency characteristics of slot radiating elements. By retuning the traveling wave resonator it is possible to shift the operating frequency band smoothly over the total range without considerably changing the directivity pattern. The use of traveling wave resonators makes it possible to create high-Q resonant slot antennas which can be tuned mechanically or electrically. This approach can be employed to create antenna systems which operate in various wave bands, since the hollow center of the traveling wave resonator can accommodate additional radiating elements. Figures 2; references 5: 4 Russian, 1 Western.  
[218-8831]

#### OPERATIONAL METHOD FOR CHECKING MATCHING OF ANTENNA WAVEGUIDE SECTIONS ON RADIO RELAY LINKS

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82 p 25

ATAMANSKIY, V. I. and KOTENKO, A. V.

[Abstract] This article describes the operating principles of IR-4 and IR-6 impulse reflectometers used for adjusting antenna-waveguide sections of radio relay links. The pulse can be produced by the microwave transmitter itself. The measurement scheme described has been used on "Druzhba" GTT-6000/1920 equipment, and can be used with any radio relay equipment. Figures 2.  
[237-6508]

## BROADCASTING, CONSUMER ELECTRONICS

### OPTICAL CABLE COMMUNICATION LINKS

Moscow VESTNIK SVYAZI in Russian No 11, Nov 81 pp 24-26

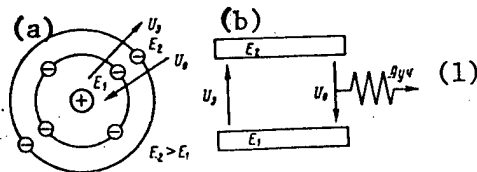
[Article by G. I. Grodnev, engineer]

[Text] The "Basic directions of the economic and social development of the USSR for 1981-1985 and up to 1990", confirmed by the 26th CPSU Congress, has the following provision: "assimilate series of new types of fiber optic communication cables". This is an extremely urgent problem, since the production of ordinary electrical cables require a great deal of copper and lead, and the reserves of these metals in the worldwide balance are extremely limited. Our cable industry consumes up to 50% of the copper and 25% of the lead from all of the country's resources. It has recently become possible to replace the lead used for cable shields with aluminum, steel and polyethylene. However, there is yet no totally satisfactory replacement for copper conductors, and the requirements for copper are increasing: there are provisions to increase the number of channel-kilometers of long-distance communications by a factor of 1.8 during the 11th Five-Year Plan, and 75% of this must use cable links. The creation of fiber-optic cables will provide a radical solution to the problem of replacing copper in cable production.

This article examines the process of transmitting energy over an optical fiber and explains the physical phenomena which are opening the way to replacing copper with glass in communication cables.

N. G. Basov and A. M. Prokhorov, creators of the optical laser quantum generator, Soviet scientists and Academicians, laid the foundation for the development of optical transmission systems. The operating principle is based on the emission by the atoms of matter under the influence of an external electromagnetic field of light quanta, or photons.

Figure 1. Laser operating principle. Key: 1, beam.



An atom of any substance (Figure 1a) consists of a positively charged nucleus and negative electrons rotating in their own orbits. The higher the orbit, the greater the electron energy ( $E_2 > E_1$ ). If electrical voltage disturbs the atom and electrons are forced into a higher orbit, when they return to their previous orbit quanta of light — photons — are emitted. Electrical energy is thus expended (pumping energy  $U_e$ ) and light energy is obtained (photon flux  $U_0$ ) (Figure 1b). This flux, passing through a resonant system of mirrors, is amplified, thus resulting in a highly directional laser beam.

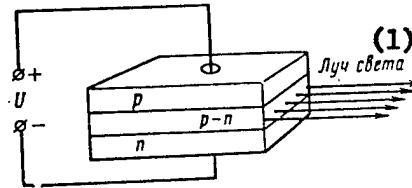
Various types of lasers are now known: semiconductor, solid-state, gas and others. A semiconductor laser (Figure 2) is a p-n semiconducting diode made of luminescent material capable of emitting light quanta or photons. Gallium arsenide with appropriate admixtures (tellurium, aluminum, silicon, zinc) are used mainly for this type of luminophor. The luminophor is excited by applied voltage, the carriers recombine and a photon flux — the laser beam — appears. Laser radiation differs from ordinary light, which represents chaotic photon movement, in that it is strictly phased and coherent, i.e., the movement of the light particles — photons — is matched in time and space.

A laser beam has a number of remarkable properties: it propagates over long distances, has strictly rectilinear direction with low divergence, and can carry a huge amount of information. Laser systems ordinarily use the visible spectrum of the optical band ( $10^{14}$ – $10^{15}$  Hz) which corresponds to micron wavelengths.

In its simplest form, a glass fiber or optical cable used to carry a laser beam uses a two-layer construction (conductor-jacket) with different refraction indexes. The beam moves along the fiber and is reflected in zig-zag fashion (repeatedly) from the conductor-jacket boundary (Figure 3a). In order to prevent the radiation of energy through the jacket into the environment, the beam is directed toward the end of the cable at an angle of  $\phi$  which is greater than the total internal reflection angle ( $\sin \theta = n_2/n_1$ ). When  $\phi \geq \theta$  (Figure 3b), there is only the reflected beam: there is no refracted beam, consequently, no energy is radiated into the environment, and all of the transmitted energy propagates efficiently along the fiber conductor. The quality and range of transmission depend on the transparency of the glass, i.e., the losses in it. The optical fibers which are now being manufactured have an average attenuation of about 5 dB/km. Developmental optical cables with fiber attenuation of 0.5 dB/km exist.

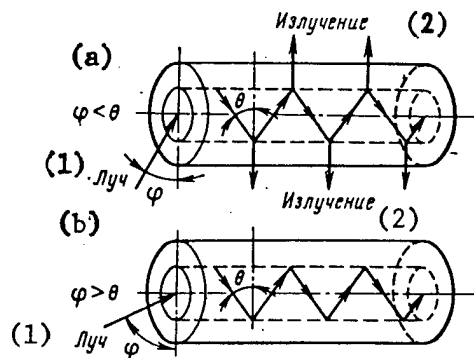
The basis of optical communications (Figure 4) is thus provided by an optical cable. The radiation source is either a semiconductor laser L or light-emitting diode SD, and the receiver is a photodiode FD. At the input to the optical cable, the electrical signals are converted to optical, and re-converted to electrical at the output. The primary system used for optical cable transmission is a digital PCM system. Systems with 30, 120, 480 or more channels are used.

Figure 2. Diagram of semiconductor laser. Key: 1, light beam.



Besides saving copper, other advantages of optical cable include their bandwidth and the capability of transmitting a large stream of information ( $10^4$ – $10^5$  channels), low attenuation and frequency independence over a wide frequency range. Optical cable attenuation at a wavelength of  $0.85 \mu\text{m}$  amounts to 5 dB/km. Investigations have established that when a wavelength of 1.3–1.7 is used the attenuation can be reduced to 0.5 dB/km, i.e., the distance between regenerators can be increased to 80 km; in addition, optical cables are small and light in weight (optical cable weighs 10 to 12 times less than electrical cable), and they are suitable for installation underground.

Figure 3. Transmission over fiber light guide: a - radiation present ( $\phi < \theta$ ), b - radiation absent ( $\phi > \theta$ ). Key: 1, beam; 2, radiation.



The high cost of production is a shortcoming of optical cables. However, as this technology is mastered the cost of optical fiber should soon drop by a factor of 10.

Optical cables have begun to be used primarily for city automatic telephone exchange trunk devices, where they replace extremely metal-intensive electrical cables. Several optical cable lines are already in operation in the USSR in IKM-30 and IKM-120 transmission systems (Moscow, Gor'kiy, Leningrad). There are plans to construct optical cable lines in other cities here during the 11th Five-Year Plan.

In the future, optical cables should be used in zone and backbone communications networks.

An optical cable is constructed of one or several light guides (fibers) arranged or twisted in a certain manner and covered with a protective plastic jacket. Reinforcing elements are often included in the jacket or center of the cable, which increase the breaking strength of the construction significantly.

Fiber light guides exist with a discontinuous profile (abrupt variation in the coefficient of refraction) and gradient fibers (in which the coefficient refraction changes continuously, most often parabolically).

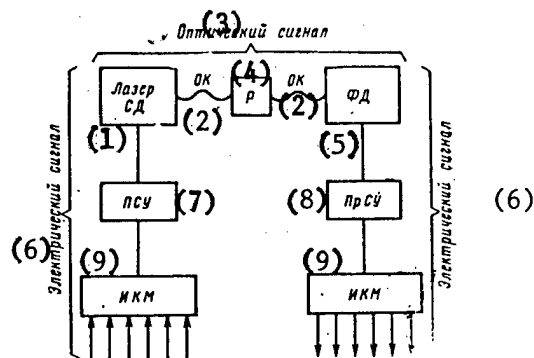
Low energy losses and low dispersion distortions are important requirements imposed on light guides. These properties are present in alloyed quartz glasses,

multi-component silicate glasses and transparent polymers. However, the use of quartz glasses provides the best results.

A two-layer quartz fiber is obtained by chemical precipitation of silicon oxide on the outside surface of a quartz tube (jacket) from the gaseous phase at a temperature of 600-800°C. In order to obtain a smooth or abrupt change in the index of refraction of the blanks, borium, phosphorus or other compounds are added to the silicon pairs during defined stages of precipitation. The blanks are then pressed into a bar and a fiber of the required diameter is drawn from it. In order to increase the mechanical strength and to provide protection against outside influences, a plastic coating of polyamide, fluoroplastic or polyethylene is put on the fiber.

Figure 4. Functional diagram of optical communications:

- 1 - laser/light emitting diode;
- 2 - optical cable;
- 3 - optical signal;
- 4 - regenerator;
- 5 - photodiode;
- 6 - electrical signal;
- 7 - transmit interface;
- 8 - receive interface;
- 9 - PCM.



The last meeting of International Electrotechnical Commission subcommittee 46E in October 1979 adopted coordinated resolutions to standardize the following geometric parameters of fiber light guides: conductor  $50 \pm 3 \mu\text{m}$ , jacket -  $125 \mu\text{m}$ , protective coating -  $200 \mu\text{m}$ .

Reinforcing elements which provide protection against mechanical stretching loads, and in some cases prevent shrinkage of plastic coatings, can be placed within the cable, or around it. Reinforcing elements which are used include both metal (aluminum, steel) and high strength braided synthetic materials (nylon, Kapron, etc.).

The exterior jacket used in optical cables are mostly of two-layer construction: first an absorbing envelope of porous plastic is put into place, and then the outside jacket, usually polyethylene. Aluminum corrugated jackets with a protective polyethylene tube are also used.

A large number of different optical cable designs have now appeared around the world. In principle, they can be classified into the following three groups: traditional twisted-layer cables (Figure 5a); cables with a shaped plastic core with the optical fibers arranged around it (Figure 5b); and cables with flat construction consisting of stacks of strips containing fibers (Figure 5c).

Cables with shaped cores are used most widely in European countries. Flat cables made of stacks of strips, each containing between 6 and 12 optical fibers are used in the US. Japanese designs are also of interest. The gradient fiber they have created has low continuation and allows communication over a distance of 80 km without amplifiers.

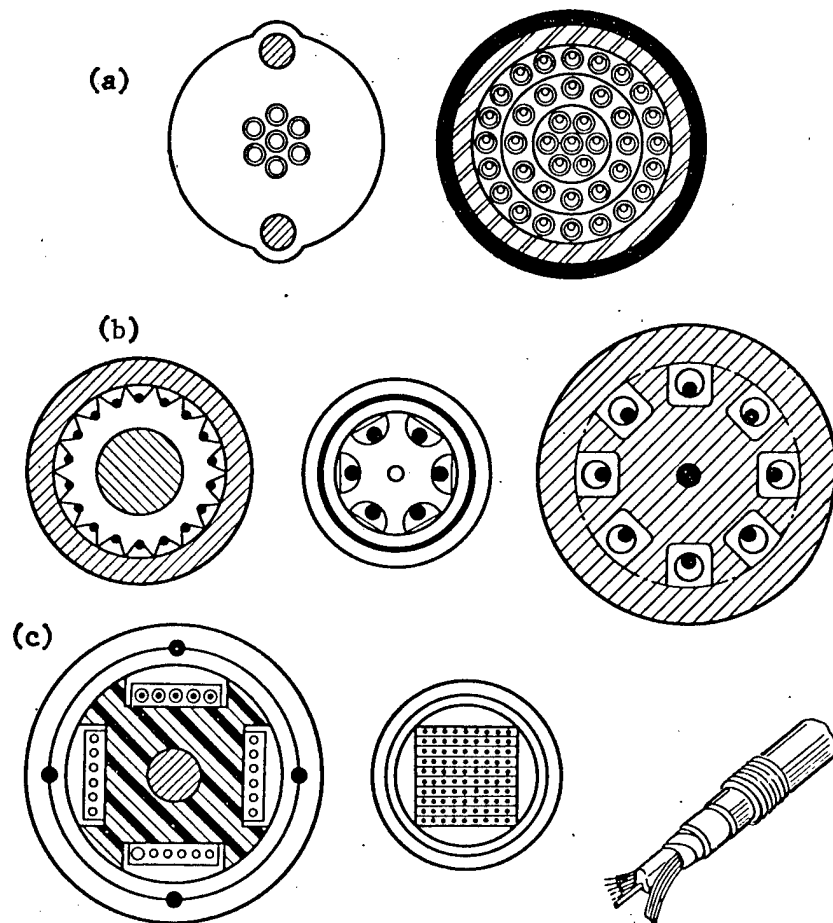
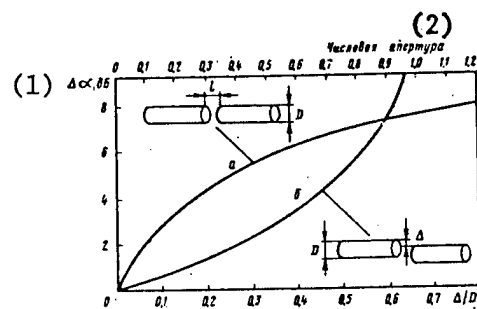


Figure 5. Optical cable construction: a — twisted layers; b — use of shaped core; c — flat construction.

Figure 6. Influence of gap (a) and lateral displacement (b) when splicing fibers. Key: 1, dB; 2, numerical aperture.



The installation of optical cables is one of the most important tasks involved in their utilization. Many different ways have appeared in recent years for joining structural cable lengths. These methods can be divided into two groups: stationary and operational installation. Stationary installation is used for cables intended for long-term operation, while operational is used for mobile reusable cables, where structural lengths must be connected and disconnected repeatedly.

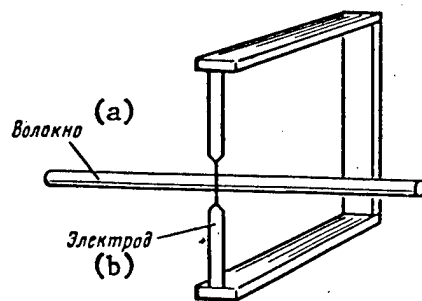


Figure 7. Electrical arc welding of fibers. a - fiber; b - electrode.

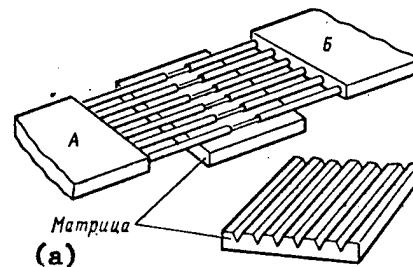


Figure 8. Arrangement of flat optical cables. a - matrix.

The main requirements for connecting devices are simplicity of construction, low transient losses, resistance to external mechanical and climatic effects and reliability. When connecting fibers they must be kept strictly coaxial, the geometry of their ends must be identical, and the ends must be perpendicular with respect to the optical axes of the fibers.

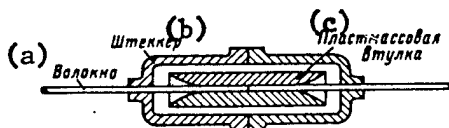


Figure 9. Plug connector  
a - fiber; b - plug; c - plastic sleeve.

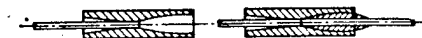


Figure 10. Capillary connection.



Figure 11. Use of heat-shrinkable tubing: a - original position; b - after heating; c - cable.

As Figure 6 indicates, end-to-end misalignment causes significant additional losses, and a gap between the fibers has a significant influence on the quality of the junction. The use of a matching medium between the ends of the fibers which has a coefficient of refraction different from that of the fiber core reduces significantly the quality of the joint.

The fiber ends are prepared by spalling and polishing them. The fibers are trued with the help of plastic tubes having the same inside diameter as the fibers being connected, or using a plastic matrix with V-shaped grooves which hold the fibers.

Electric arc welding is one method of stationary mounting (Figure 7). Nichrome electrodes are used for this purpose. A high voltage electric arc welds the ends of the fibers within two seconds at a temperature of 1000-1500°C. The junction losses are between 0.1 and 0.3 dB. The strength of the joint is 70% of that of a whole fiber.

In installing a flat optical cable (Figure 8), the fibers of the twisted ends of cables A and B are laid in the grooves of a matrix and filled with epoxy resin.

Plug-type connectors — mechanical joints which allow the construction lengths to be joined and separated — are used most extensively for operational installation. Analogous constructions are also used to connect cables to equipment. There now exists a large number of varieties of plug connectors, the most common of which is shown in Figure 9.

The following simple version of connecting fibers is of interest (Figure 10). A glass capillary with a melting temperature lower than that of the fiber is taken. The fiber with its prepared end is inserted in the capillary and held in place by locally heating the capillary and shrinking it about the fiber. Then the other fiber is inserted in the other end of the capillary and held in place with a special adhesive.

It is recommended that splices be sealed and protected with heat-shrinkable polyethylene tubing. This tubing is able to shrink in diameter when heat is applied, which produces a solid sealed jacket for the cable (Figure 11).

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CSO: 5500/1014



## TELEVISION BROADCASTING VIA SATELLITE

Moscow RADIO in Russian No 11, Nov 81 pp 5-8, 32b, 32c

[Article by V. Bykov, V. Dudkin and D. Zaytsev]

[Text]

### History

The Communist Party and Soviet government exhibit continuing concern regarding the extensive and thorough development of television in the USSR. We are doing everything to encompass the entire USSR with television broadcasting and to provide Soviet viewers, even in the most remote regions of our country, with the ability to receive Central television programming at convenient local times.

It must be emphasized that the solution of this important government problem is no simple matter, considering the extent of the territory of the Soviet Union and the presence of inaccessible places and regions with low population density. Prior to 1967, this problem could be solved only by using ground facilities. Powerful television transmitting stations (5-50 kW) and low-power relays (1-100 W) were built. The graph in figure 1 demonstrates the dynamics of the development of the terrestrial transmission network in the USSR, while figure 2 shows the availability of television broadcasting to the population by 5-year plans. It is apparent from these figures that during the early stages the construction of a ground-based transmission network was an efficient approach. Stations were built in heavily populated areas of the country, and each facility to be brought on line meant a significant increase in the number of viewers. For example, by 1 January 1961 100 powerful TV transmitters were built in this country, along with about 170 low-power relays, which provided television broadcasting to approximately 35% of the population.

However, during the following 5 years, i.e., up to 1966, when 190 powerful transmitters and 480 low-power relays were already in use, the increase in the number of viewers was only 20%. The efficiency of ground-based facilities then began to drop sharply as TV stations were brought on line in sparsely populated regions. For example, during the following 5-year plan, the addition of the same amount of transmitting hardware as was brought on line during the previous 5-year plan produced a viewer increase of only 15%.

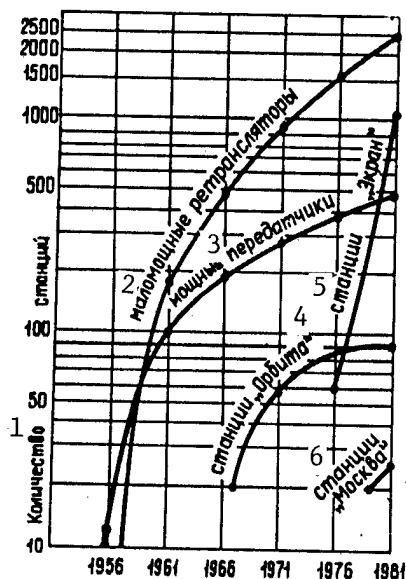


Figure 1. Development of USSR television transmission network. 1, number of stations, 2, low-power relay; 3, powerful transmitters; 4, "ORBITA" stations; 5, "EKRAN" stations; 6, "MOSKVA" stations.

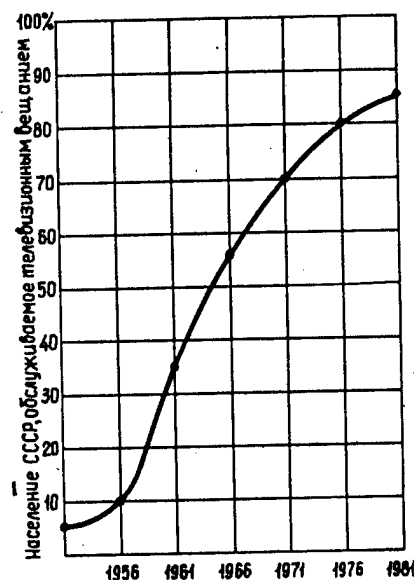


Figure 2. Availability of television broadcasting to population. 1, USSR population served with television broadcasting.

It became clear that continuing to add to the transmission network was inadvisable: in order to provide television broadcasting for 95% of the population it would be necessary to build more than 1000 powerful television stations and a large number of cable and radio relay links, which involves substantial capital investments and takes a great deal of time. It would be practically impossible to provide Central programming to 100% of the population.

A natural and fully realistic way to solve this problem within a short period was to use satellite systems, with which a single satellite could serve wide areas.

#### Technical and Economic Aspects

An important condition in the design of satellite television systems which determines their parameters and influences the choice of frequency range and technical characteristics is the economic indicator. Economically optimal systems are designed on the basis of allowing for the cost of the space complex and earth stations, as well as the level of development of the ground receiving network.

Figure 3 shows examples of the relationship between the cost of these complexes and the satellite transmitter power  $P_b$  and Q-factor (sensitivity) of the ground receiving antennas  $(G/T)_g$ . The G in the ratio  $(G/T)_g$  indicates the gain of the antenna and T designates the equivalent noise temperature of the earth station. It is apparent from the graph that the cost of the satellite and its launch depend to a great extent upon the power of the on-board transmitter. The higher the power, the greater the size and weight of the transmitter, the greater the power consumption, and the greater the size and weight of the power supplies; in the final analysis, the size and weight of the satellite are increased; requiring increased launch vehicle power.

Conversely, the cost of the receiving earth station becomes smaller, since good TV signal reception can be ensured with a more powerful on-board transmitter even when less sensitive, simpler and less expensive receiving installations are used.

Analyzing these relationships, we can reach the following conclusions:

- there exists an optimal relationship between  $P_b$  and  $(G/T)_g$  for which the overall system cost is lowest;
- the optimal values of  $P_b$  and  $(G/T)_g$  depend upon the number N of earth stations in the system. When N is large, there is a shift toward large values of  $P_b$ . Therefore, in designing mass television satellite broadcast systems it is best to use the maximum acceptable on-board transponder power, which ensures maximum simplification and cost reduction of the receiving network, and consequently of the system as a whole.

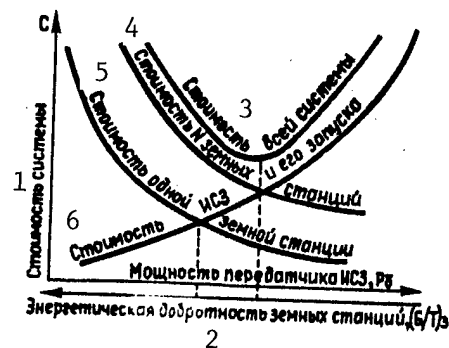
The highest acceptable relay power or, more precisely, the highest equivalent isotropic-radiated power, is determined on the basis of the Radio Communications Regulations, which limits the power flux density of satellite emission near the ground  $W_{sat}$ , in order to avoid interfering with other services, in each of the frequency bands allocated for satellite broadcasting or fixed satellite service.

According to the Regulations, television satellite broadcasting can use the 0.7 GHz, 2.5 GHz and 12 GHz bands; in addition, television can be transmitted within the framework of fixed services (to stationary ground facilities) in the 4.11 and 20 GHz bands (we shall not be considering higher frequency bands for the moment). Figure 4 shows the limitation of  $W_{sat}$  established by the Regulations for these frequency bands, as well as the maximum acceptable effective isotropic radiated power of the satellite and Q-factor  $(G/T)_g$  calculated on the basis of these values of  $W_{sat}$  which are required to provide a given reception quality. This figure also shows the values of  $(S_e/T)_e$  which are most convenient for economic calculations, where  $S_e$  is the effective antenna surface of the ground receiving facility, which characterizes its physical dimensions and therefore its cost. These relationships thus provide the basis for selecting the basic parameters of the on-board transmitter and the Q-factor (sensitivity) of the ground receiving stations  $(G/T)_e$  or  $(S_e/T)_e$ .

Keeping the ratio  $(G/T)_g$  or  $(S_e/T)_e$  constant, it is then necessary to select values of  $G$ ,  $S_e$  and  $T$  which result in the minimum cost of the earth station as a whole. These discussions go as follows: the larger the effective antenna area ( $S_e$ ), the higher its cost; however, it is acceptable to use a less sensitive receiver (with higher noise temperature), having a correspondingly lower cost, and conversely. For some optimal values of  $S_e$  and  $T$ , the cost of the entire earth station, or the sum of the costs of the antenna and receiver, becomes minimal.

These data provide the basis for determining the relative cost of economically optimal satellite systems in each of the frequency ranges. The graph in figure 5 shows the results of the analysis, whence it follows that the most economically profitable systems are those operating in the 12 GHz range, where the least limitations imposed on  $W_{sat}$  make it possible to use receiving installations with low  $Q$  and low cost. Systems operating in the 0.7 GHz range can have comparable economic indicators; the cost of building satellite television systems in the other ranges is significantly higher.

Figure 3. Cost of satellite system as function of basic parameters; 1, system cost; 2, power figure of merit of earth stations,  $(G/T)_g$ ; 3, entire system cost; 4, cost of  $N$  earth stations; 5, cost of 1 earth station; 6, cost of satellite and launch.



These considerations have made it possible to lay out a strategy in the area of selecting frequency ranges and determining the optimal parameters of satellite TV systems. However, there is another aspect which we must consider. The cost of each television receiver assumes a certain sum  $C_0$  which the television purchaser pays to the government for delivery of television programming, i.e., for the technical equipment used to transmit and distribute TV programming. Obviously, the amount the government spends to deliver a program to one subscriber must not exceed  $C_0$ . Consequently, even if we disregard the satellite cost, which makes up a significant portion of the system cost, it is still necessary to try to meet the condition  $C_{z.s}/n \leq C_0$  [1], where  $C_{z.s}$  is the cost of the earth station, and  $n$  is the number of subscribers receiving programming from that station.

This means in practice that expensive receiving stations can be deployed only in large cities, and that satellite systems with inexpensive receiving stations must be provided to serve small populated regions.

#### "Orbita" System

Satellite facilities began to be used extensively for transmitting television programming in the USSR in 1967, when the "Orbita" network of earth stations was put into operation. TV programs are fed to these stations through the "Molniya-1" satellites in the 1 GHz band. The first 20 "Orbita" stations increased the number of Central viewers by more than 20 million [2].

Intensive construction of "Orbita" stations continued in subsequent years, with facilities appearing in practically all large cities in Siberia, the Far North and the Far East. There are now 90 of these stations, and beginning in 1974 most "Orbita" stations were switched over to the 4 GHz range to operate with the "Molniya-2" satellite, and are now working with the "Molniya-3", "Raduga" and "Gorizont" satellites. Table 1 shows the basic technical parameters of the "Orbita" system.

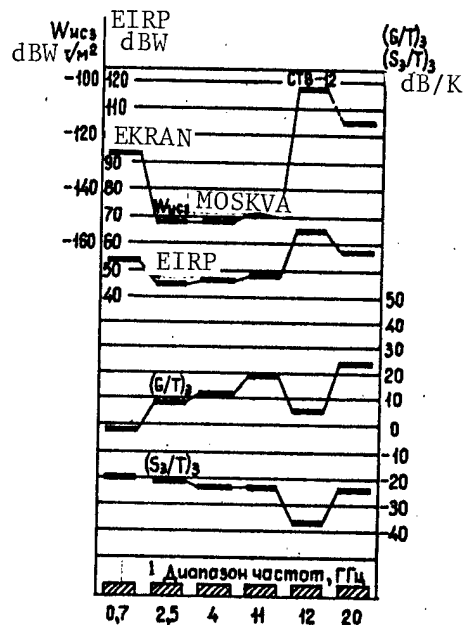
The "Orbita" stations have been described repeatedly in the technical literature [3,4]; therefore, we shall limit our attention here to only the most general characteristics. The station is based on a fully rotatable twin-reflector parabolic antenna 12 meters in diameter installed on a circular reinforced-concrete building; the building contains a liquid nitrogen-cooled input parametric low-noise amplifier, receiving equipment, an equipment complex for programmed aiming of the antenna toward the satellite, as well as a great deal of auxiliary and power equipment. The TV program received at the station is relayed to a local television center or to a powerful relay station and is sent over the air in the meter or decimeter frequency band.

Table 1. Basic Technical Parameters of Satellite Television Broadcast Systems

Parameters	System		
	"Orbita"	"Moskva"	"Ekran"
Frequency band, GHz	4	4	0.7
Satellite transmitter power fed to antenna, W	8	40	200
Satellite transmit antenna gain, dB	22	30	33.5
Effective isotropic radiated power of satellite, dBW	31	46	56.5
Modulation method	FM	FM	FM
TV signal frequency deviation (without sync pulses), MHz	9.1	9.1	6.3
Type and diameter of receiving earth station antenna, meters	12 meter parabola	2.5 meter parabola	32/4 sheet wave channel*
Receiving earth station antenna gain, dB	51.9	37.5	30/23
Equivalent noise temperature of earth receiving station, K	100	200	800/800
Power figure of merit (G/T) of earth receiving installation, dB/K	29	14.5	1/-6
Signal/noise ratio at receiver input, dB	12.5	12.5	20.8/13.8
Signal/weighted noise ratio at receiver output in image channel, dB	53	53	54-55/48
Signal/noise ratio at receiver output in sound channel, dB	57	57	53-56/49

\*The numbers in the table here and below in the numerator refer to a type-I earth station, while those in the denominator refer to a type-II station.

Figure 4. Optical parameters of satellite television systems. 1, frequency range, GHz.



The "Molniya-3" satellite is now being used to feed the first Central television program to the "Orbita" station network in areas of the Far East, Kamchatka and Chukotsk; the other "Orbita" stations are being used increasingly to receive the second Central program, which is broadcast on a local time schedule.

The "Orbita" system was the world's first multistation television distribution system. However, for a number of technical reasons the system parameters were non-optimal, and the cost of an "Orbita" earth station is very high. Therefore, their construction was economically justified only in large cities and populated areas with population of at least 50,000. Even so, "Orbita" stations were also built in relatively small areas with populations of 5-10,000; this was done in the name of, and for the welfare of, the Soviet people.

Later, when it became necessary to build stations in populated areas with a few thousand residents, the development of the "Orbita" network was halted, and the task of building new, far less expensive satellite systems was put forth.

#### "Ekran" System

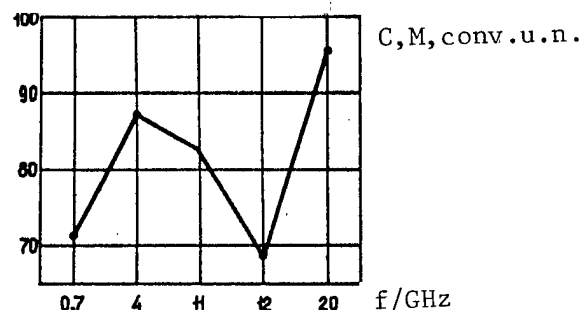
The "Ekran" system meets these requirements [5]. The "Ekran" satellite was first launched on 27 October 1976 and injected into a geostationary orbit with coordinates of 0° latitude and 99° east longitude. An experimental network consisting

of 60 receiving installations had been built by that time. The area serviced by the system encompasses 90 million square kilometers, which is about 40% of the entire country. The areas served include regions of Siberia, the Far North and part of the Far East.

The "Ekran" system was built in complete accord with the principles explained at the beginning of this article, using the 0.7 GHz band. The system uses inexpensive solid-state input amplifiers, simple wave channel multielement antennas and an on-board transceiver with the maximum possible power. This has made it possible to obtain the required signal/noise ratio and the required TV channel performance indicators while keeping the cost of the receiving installations low (Table 1). Since terrestrial television facilities also work in the 0.7 GHz band, the zones served by the system were selected so as to provide a sufficiently high power flux density in the zone and to make it possible to meet standards for interference field intensity outside the zone in territories of other governments [6].

This system is based on the "Ekran" satellite, which carries a high-power transmitter (200 W) and a huge folding phased transmitting antenna which contains 96 spiral elements (see illustration on back cover [not reproduced-Tr]). Widely spreading wings - solar batteries - provide power of up to 2 kW. The satellite's special high precision tri-axial stabilization position holds it in the required position with respect to the earth and boresights the transmitting antenna on the service zone.

Figure 5. Cost of optimal satellite TV systems in different frequency ranges.



The "Ekran" system uses two types of ground receiving stations. The first type is designed to feed high quality TV signals to powerful TV stations which serve fairly large populated areas. These sets are configured with "wave channel" antennas containing 32 sheets. The receiving equipment consists of only a single rack, which receives, amplifies, demodulates and separates the sound and picture signals. The cost of this receiving installation is significantly lower than that of an "Orbita" station. The second type of installation is designed to feed the TV signal to low-power television relays, or over a cable distribution network. These systems use 4-sheet antennas and small receiving devices which translate the signal spectrum from the received frequency of  $714 \pm 12$  MHz to the spectrum of a channel in the meter band, and convert FM to AM. These installations cost almost 300 times less than an "Orbita" station. For operating convenience, receiving installations of this type have recently been combined into a single unit with a 1- or 10-W transmitting device.

The "Ekran" system passed all of its tests successfully. Its earth stations can be installed in large populated areas, in small villages, and can even serve individual geological prospecting parties. There are now over 1000 installations for this system around the country, and the network of stations continues to expand.

Equipment is being improved at the same time: for example, an input amplifier with a lower noise temperature is now being put into use, the production of special antennas for areas with difficult weather conditions have been proposed, as has the introduction to installations of the first type of an additional audio channel to carry radio broadcast programs.

All of the above allows us to state that the "Ekran" system is an extremely efficient means for organizing television broadcasting in areas of Siberia and the Far North of the USSR. Unfortunately, however, it cannot be used in other areas of the country, since footprint coverage of areas to the east and west of the existing service zone would be unavoidable. This would create intolerable interference with ground facilities belonging to other nations. It thus became necessary to create technical equipment with analogous simplicity and efficiency to transmit TV programming to areas of the Urals, Central Asia and the Far East.

#### "Moskva" System

In accordance with the task, the new "Moskva" satellite TV broadcasting system was developed and put into operation in the heavily utilized 4 GHz band. This system (technical parameters shown in Table 1) supplements the existing "Orbita" and "Ekran" systems, and makes it possible to encompass almost the entire country with Central television programming [7].

Table 2. Utilization of Equipment for Television Program Distribution in the USSR

Broadcast Zones	<u>A</u>	<u>B</u>	<u>V</u>	<u>D</u>	<u>M</u>	USSR Total
TV program provided	"Orbita-1"	"Orbita-2"	"Orbita-3"	"Orbita-4"	1 Central	
TV program delivery facilities	"Molniya" satellite, "Orbita" station network, landline	"Raduga-85" satellite, "Orbita" station network, landline	"Ekran" satellite, "Ekran" station network, landline	"Gorizont-53" satellite, "Moskva" station network, landline	"Gorizont-14" satellite, "Moskva" station network, landline	
Provision of broadcasts to population: % coverage	76.3	84.8	85.3	81.4	88.6	86.5



Special trunks carried by the new "Gorizont" series of geostationary satellites was used to build the "Moskva" system. The 40-watt on-board transmitter combined with the unidirectional on-board transmitting antenna makes it possible to obtain the maximum possible EIRP in that frequency band. At the same time, in order to observe the standards established by the Regulations for tolerable spectral flux density ( $-152 \text{ dBW/m}^2$  in the 4 KHz band), 2.5 Hz dispersion (scattering) of the carrier, and deviation of  $\pm 4$  MHz, was introduced for the FM signal transmitted by the satellite. The problem of electromagnetic compatibility with existing ground and satellite facilities was solved in this way.

The high power flux density of the signal near the ground made it possible to use an antenna with a relatively small reflector (2.5 m) at the "Moskva" receiving station, and also to use an uncooled parametric amplifier with a noise temperature of 100 K for the input device. All of the other radio equipment is contained in one small rack similar to the receiving installation used in the first type of "Ekran" system. No special buildings are required to house it.

The "Moskva" system can accommodate one high performance television channel and two audio channels. The low frequency TV picture and audio signals sent out by the station are input to transmitting devices whose type and power depend upon the required zone of coverage. The cost of the "Moskva" stations is about the same as that of the first type of "Ekran" receiving installation.

In order to provide television broadcasting for the entire USSR, there are plans for the "Moskva" system to use 4 "Gorizont" satellites arranged in geostationary orbit at  $14^\circ$  west longitude, and  $53^\circ$ ,  $90^\circ$  and  $140^\circ$  east longitude. "Gorizont" satellites at  $14^\circ$  west longitude and  $53^\circ$  east longitude are now providing the first Central program for broadcast zones M and G (see inside front cover) [not reproduced-Tr.], and satellites at  $90^\circ$  and  $140^\circ$  east longitude will provide the following coverage: second Central program for zone B and first Central program for zone A (replacing the "Molniya-3" satellite).

An experimental network of 30 "Moskva" stations is now in operation in this country. Tests which have been completed have confirmed that the technical treatments are correct, and this network of stations will soon be expanded vigorously.

#### Future Prospects

We have now examined the principles behind the construction of optimal satellite television broadcasting systems, and have become acquainted briefly with three domestic systems. One natural question is why three systems are needed which operate at the same time. The answer follows from the task of satellite TV broadcasting as formulated at the beginning of this article — providing the population of the country with multi-program television broadcasting allowing for local time zones.

For this purpose, the entire country has been divided into five broadcast zones (cf. map inside cover) [not reproduced], each of which covers the territory of approximately two time zones. Central TV programming must be fed to each of these broadcast zones with a two-hour time shift. Thus, the first Central TV program is produced in Moscow and broadcast in zone M, along with four copies "Orbita-1", "Orbita-2", "Orbita-3" and "Orbita-4", which are delivered to the corresponding

zones A, B, V and G. Since the first program is broadcast for more than 15 hours a day, five TV channels are required simultaneously to transmit all of its copies. These channels will be provided by the joint utilization of satellite systems, as well as terrestrial radio relay and cable links.

It is apparent from Table 2 that each of the broadcast zones now uses several technical facilities to transmit TV programming. This is explained by the fact that the most efficient distribution systems — the "Ekran" and "Moskva" — were introduced relatively recently and have not yet been developed quantitatively to the required extent. They will later assume the function of national distribution of the first TV program and its copies. The "Orbita" system in conjunction with landlines will distribute the second TV program and its three or four copies.

Television in the USSR is now faced with the task of providing the same conditions for all Central television programming. The problems of distributing TV programs from the union republics have not yet been resolved completely. All of this requires that we find new technical facilities, one of which should be the 12 GHz satellite TV broadcasting system.

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## OPTICAL FIBER COMMUNICATIONS LINES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82 pp 3-4

KOTEL'NIKOV, V. A., vice-president, USSR Academy of Sciences

[Abstract] An introduction is given to a special issue of the journal RADIOTEKHNIKA, devoted to the results of Soviet research on optical fiber communications lines. The articles are grouped in four sections: optical fiber circuits and their components, systems with optical fiber communications lines, measurements in these lines, and the servicing of them. Optical fiber communications lines are regarded as promising for the creation of new measuring and data processing complexes required for monitoring and controlling energy consumption and for the development of high-speed computers and measuring systems and instruments. Plans are being made to create a new type of sensor for various physical quantities based on measuring the parameters of an optical fiber under the effect of a change in various characteristics of the environment. A survey is presented of the topics covered by Soviet and foreign publications, in relation to optical fiber communications lines. Included among the advantages of optical fiber communications lines over existing cable communications systems are the considerably greater distance between repeaters, enormous carrying capacity and a broad band of frequencies which can be transmitted, high noise immunity in terms of electromagnetic fields, low crosstalk levels, relatively low cost of materials required for creating the glass fiber and cable based on it, complete electrical insulation of input and output devices, and the relatively small size and bulk of an optical fiber cable.

[217-8831]

## OPTIMIZATION OF OPTICAL FIBER DATA TRANSMISSION SYSTEMS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 3 Sep 81) pp 68-71

BERG, V. P., GUS'KOV, N. A., OBUKHOV, N. F., POKROVSKIY, V. R. and  
STAROBINETS, I. A.

[Abstract] A variant is discussed of the design of a multiterminal data transmission system which operates through a parallel "Interfeys-T" interface with time-division multiplexing of signals. The reliability and data transmission speed are determined chiefly by the parameters of the optical fiber communications line used. An optimization procedure is discussed, consisting of two steps: 1) Determining the required transmission speed; and 2) Optimizing the main parameters of the optical fiber communications line. The operating principle and data transmission speed in a multiplexed optical interface are discussed. The "Interfeys-T" is used at group programmable user stations for interfacing the central control unit with 8 input/output units over a range of up to 500 m through 22 functional lines. Identification signal tracking is used in the transmission of bytes of data in the "Interfeys-T". A comparison is made of time diagrams for the transmission of a single byte of data from the central control unit to input/output units in a non-multiplexed and multiplexed "Interfeys-T". Calculations demonstrate that with the existing mass-produced electronic components the transmission speed in an optical multiplexed "Interfeys-T" over a range of greater than 150 m can even surpass the transmission speed in an electrical non-multiplexed interface. The "Interfeys-T" optical interface consists of a set of optical fiber communications lines of various lengths having various carrying capacities. A single line with an optical splitter cannot be used because it is difficult to guarantee the required reliability of data transmission on account of the low power of radiating elements and the existence of considerable attenuation in splitters. The system approach is used to optimize, in terms of data transmission reliability, optical fiber communications lines used in the "Interfeys-T". The optimization problem is formulated as follows: With assigned specifications for data transmission range and speed, it is required to determine the key parameters of an optical fiber line making possible the maximum signal-to-noise ratio in the receiver's output with fixed power of the transmitter. The signal-to-noise ratio here is influenced by matching of the carrying capacity of all components of the system, chiefly of the light conductor and receiver. It is demonstrated that for each line with assigned length of the light conductor and value of  $B$ , where  $B = K_i R_{VO}$ , where  $K_i$  is the redundancy factor and  $R_{VO}$  is the data transmission speed of the optical fiber communications line, optimum values exist for light conductor parameters  $\sigma$  and  $A_0$  with which the signal-to-noise ratio will be maximum, where  $\sigma$  is the linear attenuation of the light conductor and  $A_0$  is its numerical aperture. Figures 5; references 3: 2 Russian, 1 Western.  
[217-8831]

## OPTICAL FIBER DATA TRANSMISSION SYSTEMS FOR AUTOMATED CONTROL SYSTEMS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 3 Sep 81) pp 65-67

BERG, V. P., VOROTNIKOV, V. L., GUS'KOV, N. A., KISLENKOV, G. V.,  
MAKOVETS, G. K., OBUKHOV, N. F., POKROVSKIY, V. R. and YUDENKOV, V. S.

[Abstract] A description is given of the VOSPI-T and VOSPI-7920 model optical fiber data transmission systems (VOSPI's) developed to replace electrical lines operating through the "Interfeys-T" and YeS-7920 interfaces used for interfacing a computer with peripherals in an automated control system. The replacement of electrical lines by optical makes it possible to reduce considerably the amount of cable used in parallel interfaces for the multiplexing of signals and to reduce crosstalk, as well as to gain the other advantages of optical fiber communications lines. The VOSPI-T is based on the following engineering solutions: time-division multiplexing of the information of parallel lines of the interface into a single serial line; the transmission of serial data in the form of pulse signals in 1V2V format; the separation of synchronizing signals by the correlation method at the receiving end of the serial line; filling pauses in the transmission of data in the serial line with 1V2V format signals; using band amplifiers of the photodetector's signal in receiving units; dividing and uniting signals of the group control unit and input/output units in the electrical part of the system; and a self-contained structure for the system in terms of design and power supply. The VOSPI-T system consists of individual structurally complete units, including a group conversion unit (BPG) alongside the group control unit (GUU) and eight unit conversion units (BPU's) alongside the input/output units. The BPG is connected with the BPU's by means of KVSP-50 optical cables. The BPG includes a conversion unit, eight optical transmitters and eight receivers, and the BPU includes a conversion unit and one optical transmitter and one receiver. The VOSPI-7920 unit is also self-contained and consists of individual identical units arranged around a control unit, and of the control unit and two optical cables. Each unit contains a coder, decoder and circuit for matching the input and output with the interface line, which altogether are called the conversion unit, as well as a transmitter and receiver of optical signals and a power supply. Figures 2; references 7: 5 Russian, 2 Western.  
[217-8831]

## LARGE-APERTURE OPTICAL FIBERS WITH RIGID OUTER COATING

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 4 Nov 81) pp 75-80

ALEKSANDROV, I. V., FEL'D, S. Ya. and SHUSHPANOV, O. Ye.

[Abstract] Optical fibers with homogeneous glass conductor and polymer shell feature low losses under excitation and at bends, but their numerical aperture decreases sharply as the temperature drops. Here the mechanism of this decrease of numerical aperture due to cooling is analyzed by establishing the temperature dependence of the refractive index for a glass-polymer fiber as well as the role of the physical properties (coefficient of linear thermal expansion and Poisson ratio) of the polymer and the role of fiber dimensions (ratio of outside radius of polymer shell to radius of glass conductor inside). The changes in numerical aperture are essentially attributable to changes in the polymer density due to temperature changes. On this premise is developed a modification of the fiber design. This includes coating the polymer shell with a thermoplastic material such as polystyrene, silicone elastomer, or polymethyl methacrylate. From the equation of thermoelasticity for thermal deformation of a triple-layer cylindrical structure are determined parameters of the coating process and dimensional parameters of the fiber layers which will ensure satisfactory performance within a given temperature range. Typically, deposition of a coating from a melt can extend the range of operating temperatures by 30°, while doping the glass conductor with germanium extends it by only 10°C with the same increase of the numerical aperture. Figures 3; references 11: 9 Russian, 2 Western.  
[203-2415]

UDC 535.375 : 681.7.068.4

## STUDY OF CHARACTERISTICS OF FIBER LIGHT GUIDE BY BACKSCATTERING METHOD

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 9 Nov 81) pp 79-84

GRIGOR'YANTS, V. V. and CHAMOROVSKIY, Yu. K.

[Abstract] The backscattering method, also called the OTDR (Optical Time Domain Reflectometer) method, is used to diagnose optical fibers and cables based on them and has the advantages: 1) That it makes it possible to determine the distribution of attenuation of light over the length of an optical fiber and cable without destroying them and when access to only one end is possible; 2) That it is a sufficiently general-purpose method suited for studying a number of parameters of optical fibers; and 3) That it can

be used to study various physical processes and to create distributed sensors. The theory of the backscattering method is discussed and the most widely used variants of the practical implementation of the method, in addition to its basic application for studying the properties of fiber light guides, chiefly of the multimode type, are discussed. The OTDR method was suggested by M. K. Barnoski and S. M. Jensen (1976), and by S. D. Personik (1977) in Western journals. It is evident from the theoretical discussion that changes in all parameters of fiber light guides result in a change in the backscattering signal and therefore it is important to know the individual contribution of fluctuations of each parameter to the total signal. The greatest influence is exerted by variations in the numerical aperture along the length of the light guide and the backscattering pattern is very sensitive to variations in the diameter of the light guide's core. The experimental apparatus for practical implementation of the backscattering method includes a pulsed light source, i.e., a laser with sufficiently high radiated power, a light divider to separate light flux traveling in opposite directions and a photodetector and a system for processing measuring results. An arrangement is suggested which utilizes a high-power pulsed ionized argon - neodymium laser in combination with a multimode light guide approximately 300 m long, making it possible to study backscattering over a broad region of the spectrum. In addition to application of the method in measuring attenuation, the method makes it possible to gain additional information on the mechanism of attenuation, e. g., on the distribution of  $\text{OH}^-$  ions over the length of the light guide. It also makes it possible to identify local inhomogeneities, such as imbedded particles, in the light guide's core. Studying backscattering is a very sensitive method for studying fiber couplers. Figures 5; references 28: 5 Russian, 23 Western. [217-8831]

UDC 621.327.8 : 681.7.068

#### OPTICAL FIBER INTERFACES FOR COMPUTING SYSTEMS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 1 Oct 81) pp 72-78

KALMYKOV, I. V., KORZINKIN, V. S., KUZ'MIN, V. I., PROKHOROV, A. M.,  
SIMACHEV, N. D., SISAQYAN, I. N. and CHERNYSHEV, A. P.

[Abstract] The extensive practical utilization of optical fiber communications lines in computing systems is hampered at the present time by the absence of a methodology for designing an optical fiber communications line for a specific purpose. Questions relating to choosing methods of designing and to synchronizing and using optical fiber communications lines for computer interfaces are discussed. The approach of finding the optimum variant is applied. An algorithm is presented for determining the optimum branch of a problem-oriented graph. This algorithm can be used not only for designing the entire system but also for solving particular problems. The final variant is shown to be one in which cycle synchronization is accomplished

by means of start pulses which differ in duration from information pulses, with equalization of the amplitude-frequency response of the receiving channel. Two examples are given of the practical implementation of optical fiber communications lines in computing systems using CAMAC equipment, minicomputers of the "Elektronika-60" type and YeS [Unified Series] computers. The purpose of creating optical fiber interfaces is to replace the great number of wire lines ordinarily required by two optical fiber light guides. The synchronous principle of operation must be implemented in a CAMAC-"Elektronika-60" interface and the asynchronous principle in the input/output interface for a YeS computer. Optical fiber interfaces all use time-division multiplexing, pulse position modulation, equalization and minimum transmission delay. An interface with optical fiber communications lines created for linking an "Elektronika-60" computer and CAMAC controller makes it possible to replace 62 wire lines with two optical fiber light conductors. The probability of error of this interface is not worse than  $10^{-9}$  and it utilizes optical fiber cables with a core diameter of 60 microns, a light-emitting diode, superluminescent diode or semiconductor laser as a radiating source, a pin diode as a photodetector and series 131, 155 and 531 microcircuits. An interface created for YeS computers is designed as an accessory to existing standard equipment and has a clock frequency of 60 MHz with an added delay of not greater than 900 ns per byte of transmitted information and transmission error probability of not greater than  $10^{-9}$ . Figures 10; tables 2; references: 2 Russian. [217-8831]

UDC 621.372.8.029,7

#### POLARIZATION PROPERTIES OF SINGLE-MODE AND FEW-MODE FIBER LIGHT GUIDES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 23 Oct 81) pp 26-29

GUR'YANOV, A. N., GUSOVSKIY, D. D., DEVYATYKH, G. G., DIANOV, Ye. M., KARASIK, A. Ya., KOZLOV, V. A., MIRAKYAN, M. M., NEUSTRUYEV, V. B. and PROKHOROV, A. M.

[Abstract] A description is given of single-mode fiber light guides with strong and mild birefringence and the results are given of a study of polarization properties of these light guides under external influences. The experimental apparatus for measuring the polarization characteristics of these light guides consists of an He-Ne laser with wavelength of 0.63 micrometer serving as the source of linearly polarized radiation, and a combination of quarter-wave plates and a polarizer making it possible to introduce into the light guide, by means of a microlens, linearly polarized radiation with any polarization angle. The ends of the light guide are immersed for the purpose of reading sheath modes. The polarization state of the output radiation passing through the lens and a diaphragm and striking a photodiode is analyzed by means of an analyzer or a Senarmont compensator. The single-mode light guide with mild birefringence studied had a nominally round core



of  $\text{SiO}_2 + \text{GeO}_2$  and a sheath of  $\text{SiO}_2$  and was fabricated by the CVD (chemical vapor deposition) method. The difference in refractive indexes of the core and sheath was  $2.4 \cdot 10^{-3}$  and the characteristic parameter at wavelength of 0.63 micrometer equaled 2.3. The phase delay was determined by means of a Senarmont compensator when exciting the light guide with linearly polarized radiation with an angle of 45 degrees to the principal axes. The measured delay equaled 15 deg/m. The results show that a high degree of polarization of the output radiation is maintained in a light guide of this type over a length of 100 m with two perpendicular orientations of the direction of polarization of the introduced radiation coinciding with one of the principal axes of the light guide. A study of the influence of bends and twists on the amount of birefringence in a single-mode light guide with mild birefringence demonstrated that the polarization state in a light guide of this type is sensitive to external influences. This property can be exploited to create various optical fiber sensors. Single-mode light guides with mild ( $2.6 \cdot 10^{-8}$ ) and strong ( $1 \cdot 10^{-5}$ ) birefringence are both able to maintain linear polarization under single-mode conditions. Figures 4; references 13; 4 Russian, 9 Western.  
[217-8831]

UDC 621.372.81.09

#### FREQUENCY RESPONSE OF FIBER LIGHT GUIDES

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(manuscript received 4 Nov 81) pp 29-34

BABKINA, T. V., GRIGOR'YANTS, V. V. and SMIRNOV, V. B.

[Abstract] A study is presented of experimental evaluation of the information properties of fiber light guides of various types. The information properties of various light guides differ drastically and they often impose major limitations on the length of optical fiber communications lines. Recently more and more often the concepts of the transfer function and response function have been used in studying fiber light guides. It is demonstrated that the formalism of frequency response is based on a Fourier transform of pulsed optical signals. Parameter  $h(\omega)$ , representing the Fourier spectrum of the response function, is often called the complex gain and  $|h(\omega)| = A(\omega)$  is called the amplitude-frequency response. The phase-frequency response is symbolized by  $\phi(\omega)$ . The frequency response of a fiber light guide exists in the physical sense only in the vicinity of the carrier, but since transmitted information is in a time relationship to the carrier's envelope, the frequency response can be defined as the dependence on frequency of the frequency gain of the envelope of the optical signal with intensity modulation. Deviation of the real amplitude-frequency response in the region of a droop from a linear relationship and the change in the slope of this droop are usually regarded as amplitude-frequency response characteristic properties in analyzing frequency response.

The same holds true, analogously, for phase-frequency response. A time method is suggested for measuring frequency response whereby pulsed optical signals are recorded in the input and output of a fiber light guide and they are jointly processed in the time or the frequency region. The process of measuring pulsed optical signals inevitably introduces distortions into determinations of frequency response. The conditions for obtaining an undistorted frequency response are derived and a discussion is presented of the influence of the multimode conditions for the propagation of optical radiation by a fiber light guide on the form of the amplitude-frequency response. The influence of excitation conditions on the form of the amplitude-frequency response and the bandwidth is discussed. Excitation conditions determine the distribution of energy between modes propagated through a fiber light guide. The dependence of the bandwidth on the angle of entry of radiation into a fiber light guide is discussed. A study of the frequency response of specific fiber light guides made it possible to conclude that it depends as a rule on excitation conditions, the length of the light guide and the refractive index profile. It is recommended that measurements be made of the frequency response of specific fiber light guides by using a mode mixer in the light guide's input and that the results be included on the light guide's data sheet. This method makes it possible to obtain highly reproducible measurement results regardless of the excitation source. Figures 4; references 13: 2 Russian, 11 Western.  
[217-8831]

UDC 621.372.81.09

PRODUCING BLANKS OF 'GRADAN' OPTICAL FIBERS IN AUTOMATED EQUIPMENT  
(MODEL UIZS-1)

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 9 Nov 81) pp 70-75

GRIGOR'YANTS, V. V., ZHABOTINSKIY, M. Ye., IVANOV, G. A., ISAKOV, V. N., KORENEVA, N. A., NOVIKOV, A. G., PETYUKEVICH, V. V. and STOROZHEV, V. V.

[Abstract] Blanks of optical fibers are most widely produced by chemical deposition from the vapor phase, a process which yields single-mode and multimode fibers with excellent performance characteristics. The necessary profile of the refractive index is attained by doping the quartz glass with various impurities and varying their concentration in layers successively deposited during forward and reverse strokes of the heating torch. Automatic programmed preparation of the initial vapor-gas mixture and profiling of the fiber blank is the only possible way to achieve the desired characteristics. The first equipment of this kind in the Soviet Union, the model UIZS-1, was developed at the Institute of Radio Engineering, USSR Academy of Sciences, and its Special Design Office for production of "Gradan" optical fibers. It has been in operation successfully for 3 years. It consists of two main quartz tubes, on both sides of a multinozzle gas torch, two

travel-limit switches, a gas flow regulator, a filter, four Teflon bubbler-batchers ( $\text{SiCl}_4$ ,  $\text{BBr}_3$ ,  $\text{POCl}_3$ ,  $\text{GeCl}_4$ ), a control module, a programmer with a 15VSM-5 or D-3-28 control computer, a neutralizer of reaction products (with 10-20 wt.% NaOH solution) with a powder scrubber, and a drying station. It produces a line of gradiental fibers with typical characteristics: outside diameter  $120 \pm 5$  micrometer (multimode  $150 \pm 3$  micrometer), core diameter 5-7 micrometer (multimode  $60 \pm 3$  micrometer), attenuation 3-6 dB/km at 0.85 micrometer wavelength, numerical aperture  $\Delta n = 0.004-0.006$  (multimode 0.2-0.4), signal dispersion in multimode fiber 0.6-4 ns/km. The authors thank members of the Special Design Office for help in building the UIZS-1 equipment, and members of the Institute of Radio Engineering V. A. Detinich, A. A. Zamyatin for extruding optical fibers, T. V. Babkina, S. V. Mertsalov, Yu. K. Chamorovskiy and S. V. Shreyber for measuring the parameters of optical fibers. Figures 6; tables 1; references 8: 2 Russian, 6 Western. [203-2415]

UDC 621.373.826 : 621.396

# DEVICE FOR WELDING OPTICAL FIBERS AND ITS EXPERIMENTAL USE IN FABRICATING ELEMENTS OF MEASURING INSTRUMENTS

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ZHARKOV, K. I., NAYDA, B. P., OLEYNIKOV, A. D., PERSHAKOV, V. V. and  
KHOVRACHEV, V. G.

[Abstract] A description is given of optical fiber splitters and their fabrication technology, and a device for fabricating them. Splitters are employed in various measuring instruments used in testing optical fibers and cables under production conditions and in use in communications lines. The device consists of a high-voltage unit and mechanical adjusting unit on which electrodes are installed, between which an electric arc originates when high voltage is supplied from the source. A thyristor control circuit connected to the primary winding of a high-voltage transformer makes it possible to regulate the arc's burning mode over a wide range. The transformer's secondary winding is connected to welding electrodes. The arc current can be varied from 4 to 22 mA, making it possible to weld optical fibers of various diameters and compositions, and a milliammeter is provided on the high-voltage source's face panel for the purpose of indicating the arc's current. The optical fibers are laid in a V-shaped channel on the stage of the mechanical assembly and are fastened in special clamps, one of which makes it possible to feed the fiber lengthwise. Two vertically positioned tungsten electrodes are brought to the fibers to be welded so that the welding point is located between the ends of the electrodes. A special magnifying lens is provided for precise alignment of the welding point and electrodes. After adjustment, the high-voltage source is switched on and an arc discharge originates between the electrodes and the fibers are welded. The welding unit has been used to produce two kinds of splitters,

one made of multicomponent glass and one made of quartz glass. The splitters were fabricated from fibers having an external diameter of 80 microns and a center core diameter of 60 microns, in the first case. The welding of a shorter length to a longer length at the latter's approximate midpoint, for example, results in symmetric positioning of the leg of the resulting Y-connection relative to its two prongs. This symmetry is the result of surface tension originating in the welding process. Quartz glass splitters were made from fibers having a diameter of 150 micrometers and a center core diameter of 60 microns. The ends of the fibers were ground at an angle of 1 to 2 degrees to their axes and were joined together at the resulting flat surfaces, and the connecting point was welded. The welded section was then trimmed and ground to a diameter equal to the diameter of the welded fibers. Figures 3.  
[217-8831]

UDC 621.383.4

INTERCOMPONENT INTERACTION IN MULTIELEMENT INTEGRATED PHOTODETECTORS FOR OPTICAL FIBER COMMUNICATIONS LINES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 5 Oct 81) pp 43-47

OSINSKIY, V. I., VRUBLEVSKIY, L. L., ZALESSKIY, V. B. and  
MALYSHEV, S. A.

[Abstract] Increasing the degree of integration results in an increase in interaction between components of integrated circuits; in multielement photodetectors this results in a reduction in spatial resolution. The creation of high-speed multielement photodetectors for optical fiber communications lines is discussed, along with methods of reducing cross-talk between the elements of a photodetector. High-speed multielement integrated photodetectors can be created on the basis of pin photodiodes, representing one of the most promising kinds of structures for them. In order to produce a low level of crosstalk it is necessary to make it possible to absorb all the radiation within the limits of the photodetector's space charge region. In order to obtain a high crosstalk attenuation factor with long-wave radiation a space charge region of great width is necessary. The preferred method of achieving this is to reduce the active thickness of the structure and create a reflecting metallic coating on the back side. In structures of this sort the p- and n-regions are made fairly thin and the thickness of the active region of the photodetector, which is the region which gathers generated photocarriers, is reduced to the dimensions of the space charge region. The reflecting metallic coating turns the radiation which passes through the structure without absorption back into the bulk of the semiconductor. Multielement integrated photodetector structures were developed and studied in which the active regions were produced by two methods: 1) By selective chemical etching of local

membranes of specific thickness; and 2) By the creation of thin isolated single-crystal regions in a supporting substrate of polycrystalline silicon. Crosstalk was reduced in structures of the membrane type by introducing between the photodetector wafers with a concentration gradient an impurity promoting the separation and transfer to the nearest p-n junction of carriers generated by radiation. These photodetector structures have 20 photodetection elements arranged in two rows with spacing of 300 micrometers. Curves illustrating the dependence of the crosstalk attenuation factor on the distance between photodiodes in a multielement photodetector show that in structures with dielectric isolation higher crosstalk attenuation is possible than in a membrane structure. With a distance between elements of 250 micrometers it is possible to produce a crosstalk attenuation factor equal to or greater than 60 dB for optical radiation with wavelength of 0.9 micrometer. Multielement photodetectors with dielectric isolation of elements with a distance between elements equal to or greater than 250 microns can be used in communications lines for transmitting digital and analog information, whereas those of the membrane type can be used only in lines for transmission of digital information. Figures 5; references 4: 2 Russian, 2 Western. [217-8831]

UDC 621.391.029.7

# AUTOMATED MEASURING COMPLEX FOR STUDYING PARAMETERS OF OPTICAL FIBER COMMUNICATIONS LINES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82 pp 84-87

ANISHKEVICH, N. N., LUKASHEV, V. M. and VIZNER, A. A.

[Abstract] Automated measurement of the parameters of elements of optical fiber communications lines in the time region is discussed, as well as a measuring complex designed for this purpose. The basic components of the measuring system are an "Elektronika 100-I" minicomputer, a data transmission interface and S7-9 sampling oscillograph, a program-controlled sweep unit, two F-4222 analog-digital converters, two F-723/1 digital-analog converters, and a nanosecond-range optical test signal generator including a wideband electrooptical modulator utilizing a lithium tantalate crystal, and a pulse shaper utilizing charge-storage diodes. The electrooptical modulator has parameters which are optimum for conditions of wideband modulation. This modulator operates in the traveling wave mode and the carrier and modulating waves are in synchronism over a wide frequency band with the characteristic impedance of the modulator and exciting waveguide matched. The electrooptical modulator consists of electrodes, a lithium tantalate crystal, fluoroplastic plates, high-frequency connectors and a case. Birefringence is thermally compensated by means of an optical and electronic circuit for the purpose of stabilizing the modulator's parameters over a wide temperature range. The modulator contains two

identical crystals whose optical axes are antiparallel and are separated by a half-wave plate. High-frequency coaxial connectors connected to the modulator's electrodes are used for input and output of the modulating signal. The modulator's half-wave voltage is 35 V. The position of the electrooptical modulator's working point in the maximum contrast region is stabilized by means of a specially developed electronic unit. The computer controls the measuring process and converts from time parameters to frequency parameters by employing a discrete Fourier transform. The measuring complex described makes it possible to expand the capabilities of standard instruments and to program and automate the process of obtaining and processing experimental data in selecting and matching the elements of optical fiber communications lines. Figures 5; references: 2 Russian. [217-8831]

UDC 621.394.42

#### RING-TYPE OPTICAL FIBER DIGITAL CHANNEL SYSTEM

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(manuscript received 2 Feb 81) pp 48-50

ABRAMOV, V. V., ARION, I. S., ZHABOTINSKIY, M. Ye., KITAYEV, A. Ye.,  
SOKOLOV, A. V., SOSNIN, V. P. and FRANTSESSON, A. V.

[Abstract] A description is given of a ring-type optical fiber system designed for transmitting information in digital form between 10 sources and receivers of signals. A ring structure makes it possible to reduce to a minimum the number of optical transmitters and receivers and the length of connecting optical cables. In addition, organization of the system's operation is considerably simplified, its adaptability for executing various communications tasks is increased and fuller use is made of the carrying capacity of channels. The ring structure is distinguished by the decentralization of multiplexing, separating and switching equipment. A system is suggested which includes a single receiving-and-transmitting control unit and nine receiving-and-transmitting units interconnected by segments of optical fiber cables. Information is disseminated in a single direction and the system utilizes time-division multiplexing with the assignment to each station of a time interval for transmitting information. The control unit forms a frame of eight 10-bit words and is in charge of organizing communications and synchronization. The control unit generates a train of synchronizing pulses 50 ns long which are grouped into frames. Each frame contains eight synchronizing pulses separated by equal intervals with an interval between frames equal to 100 ns. Each receiving-and-transmitting unit including the control unit time-selects the pulses propagated through the ring. After each recognition of a synchronizing pulse it is regenerated and 100-ns time intervals start to be read. Each unit transmits its information only during the time interval assigned to it after each synchronizing pulse. As each synchronizing pulse is propagated through the ring information appears from each receiving-and-transmitting unit and a word is formed.

The first bits of information from the bytes entered into each unit are arranged in the first frame in the first word, the second bits in the second word, etc. When information is received by each unit the bit of the first word received is entered into the first position of the data output unit, the bit of the second word received into the second, etc. Each unit sends its information into the system from which it can be withdrawn by any other unit or by all together. Figures 3; references 3: 1 Russian, 2 Western. [217-8831]

UDC 621.396.029.7

#### OPTICAL FIBERS AND OPTICAL FIBER CABLES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82 pp 5-9

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[Abstract] A summary is given of successes achieved and problems faced in the creation of optical fibers and optical fiber cables. The core and sheath of light guides developed and used with the greatest success at the present time are made of quartz glass doped in various combinations with Ge, P, B and F. The various types of light guides produced by industry are discussed briefly, including multimode light guides with a gradient refractive index profile, multimode light guides with a step-type refractive index profile, and single-mode light guides. The second type is considered quite promising for intrasystem communications lines in combination with light-emitting diodes. In light guides based on quartz glass the regions of minimum optical losses and the maximum transmission band almost agree, making the 1.3 to 1.6 micrometer waveband very promising for use in wide-band long-distance optical fiber communications. A brief description is given of the various technologies used in the manufacture of optical fibers, all of which are based on the deposition of layers of quartz glass from the gas phase. These technologies include the method of chemical deposition from the gas phase inside a quartz glass supporting tube, the method of external chemical deposition from the gas phase onto the side surface of a cylindrical support, and the method of axial deposition onto the face of a quartz glass seeding rod. The last method is the only potentially continuous method of fabricating stock for light guides. Problems faced include reducing the cost of optical fiber cables by totally automating the technological process; creating radiation-resistant optical fibers; the creation of high-strength optical fibers; and the creation of single-mode optical fibers which will support linear polarization of transmitted radiation. A promising way to solve the last problem is to use light guides with an elliptical core. There have been no published data on the creation of infrared light guides with low attenuation levels but extensive research is being done along this line. The main problem in the manufacture of cables is to avoid breaking the optical fibers and the increase in optical losses during manufacture and use of the cable. Microbends in optical

fibers are a main source of increased optical losses. It is believed that the basic difficulties along the road to creating optical fibers and optical fiber cables with specific parameters have been overcome at the present time.

[217-8831]

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#### LAYING OPTICAL CABLE IN URBAN TELEPHONE CABLE SYSTEM

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GOL'DFARB, I. S., PROSHAY, L. L., SMIRNOV, V. I., FILIMONOV, V. P. and  
CHERTOV, V. G.

[Abstract] A procedure is suggested for preparing an optical fiber cable for laying in an urban telephone cable system, and for laying it, along with the results of a final measurement of attenuation. The procedure was tested in the Moscow and Gor'kiy telephone cable systems, with 28 sections of cable with end-to-end lengths of 200 to 900 m. Cables were laid in free and occupied ducts manually in a single direction. The spool with the cable was placed on special trestles. The cable was advanced at a rate of not greater than 0.5 m/s and the longitudinal force applied when drawing cable with densely packed fibers was not greater than 200 N and 400 N with loosely packed fibers. When being laid in cable manholes the cables were laid onto brackets with observance of the permissible bending radius and were fastened to fixtures at their end points. Elastic separators were placed between the cable and supporting structures. Specially designed cable lugs are described which are designed for laying optical fiber cables without damaging them. A cable connector is fastened by means of screws to the cable's outer sheath and the lug is fastened to the flange of this connector. The lug is designed to accommodate a drawing cable. The reinforcing strands of the optical fiber cable are fastened to the lug assembly. Measurements of attenuation demonstrated that the presence of microcracks in an optical fiber cable prior to laying it considerably increases attenuation after the cable has been laid. Figures 6; references: 2 Russian.

[217-8831]



## LIMITING SPEEDS FOR TRANSMISSION OF DATA THROUGH FIBER LIGHT GUIDES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 12 Oct 81) pp 35-43

BELANOV, A. S. and DIANOV, Ye. M.

[Abstract] A study is presented of the transmission characteristics of single-mode light guides whose dispersion and energy characteristics were studied in previous papers by the authors (1976-1979). The influence of dispersion of the first order on transmission of a signal is discussed. On the basis of theoretical and experimental results it is concluded that it is possible for material and waveguide dispersion to compensate one another. In order to realize this, when working with radiation sources whose wavelength is less than 1.27 to 1.30 micrometers, when positive material dispersion is observed, it is necessary to operate in the region of values of parameter  $V$  with which waveguide dispersion is negative, where  $V = 2\pi a \sqrt{n_1^2 - n_2^2} / \lambda$ , where  $n_1$  and  $n_2$  represent the refractive indexes of the core and sheath, respectively, of the light guide. It is also demonstrated that 3-layer light guides with  $n_1 > n_3 > n_2$  can make possible total compensation of material dispersion of the first order over the entire range of wavelengths employed. Material dispersion of the first order was calculated for pure quartz, quartz heavily doped with germanium and quartz doped with boron. The results are given of a study of the propagation of a real Gaussian pulse in a regular waveguide taking into account the spectral line width of the radiation source. An expression is derived for determining the optimum duration of input pulses with which the duration of output pulses will be minimum and the data transmission speed will consequently be maximum. A study is presented of the influence of dispersion of the second order on transmission of the signal for the case when total dispersion of the first order equals zero. For this case stretching of the Gaussian pulse is calculated and expressions are derived for the optimum duration of this pulse with which the length of the output pulse will be minimum and the data transmission speed will consequently be maximum. Under the conditions cited, for sources with a spectral line width of less than 0.8 nm data transmission speeds of up to 100 Gbits/s are achievable for transmission over a distance of 100 km. Figures 11; references 15: 12 Russian, 3 Western.

[217-8831]

## HIGH-SPEED REPEATER OF PULSE SIGNALS OF OPTICAL FIBER COMMUNICATIONS LINE

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 15 Oct 81) pp 55-56

AKSENOV, Ye. A., LOGGINOV, A. S. and RZHEVKIN, K. S.

[Abstract] A description is given of an optical signal repeater which corrects a light pulse by simultaneously restoring its amplitude and duration with a data transmission speed of greater than 1 Gbits/s. High-speed repeaters are required for optical fiber communications lines of great length in order to solve the problem of regular restoration of the parameters of the transmitted signal, which is affected by attenuation in the fiber and by dispersion which results in broadening of the light pulse propagated through the fiber. The repeater is based on a high-speed threshold element in the form of a controlled Gunn diode. The Gunn diode is triggered by a signal originating in a photodetector when the light pulse propagated through the fiber reaches it. An injection laser is excited by means of pulses of fixed amplitude and duration generated by the Gunn diode. In the starting state, in the absence of a trigger pulse, fixed voltage is established between the cathode and anode of the Gunn diode, which creates a field of approximately 3.2 kV/cm, whereby a certain current flows through the Gunn diode. A negative-voltage trigger pulse arrives at the Gunn diode's control electrode and increases the resistance of the depletion region beneath the contact, as a result of which the field under the contact increases and with an increase above the critical value a domain begins to form under it. The formation of this domain results in reduction in current flowing through the Gunn diode. It is necessary to use a Gunn diode with the length of the active region  $l \geq 10^{-2}$  cm. The maximum power gain of the repeater is determined by the ratio of the light power added to the fiber as the result of repeating to the minimum light power necessary for triggering the Gunn diode with the threshold trigger voltage. Experiments have been conducted which confirm the workability of the suggested repeater. The repeater is well suited for integrated design. Figures 3; references 7: 2 Russian, 5 Western.  
[217-8831]

## DUPLEX TRANSMISSION OF DATA THROUGH SINGLE-FIBER OPTICAL CHANNELS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 5 Oct 81) pp 57-60

BOBROV, Ye. S., DAVIDOVSKIY, S. V. and TAFEYEV, O. A.

[Abstract] The two-way transmission of data through a single light guide makes it possible to increase the utilization of the wideband properties of an optical fiber. An illustration is given of a single-fiber communications line in general form; in a line of this type there must be a unit for uniting and separating the receiving and transmitting channels and this unit can be either optical, electronic or electrooptical. A summary is presented of the various methods of reversible uniting of optical information. It is demonstrated that taking into account the state of the art of existing components the simplest way to construct a single-fiber line is a circuit utilizing directional couplers and electronic controlled rectifiers. The basic specifications for a coupler are low attenuation in the direct transmission channel and high crosstalk attenuation. Ideally, in a coupler with a power division factor of two attenuation equals 3 dB, and in order to make possible an attenuation span of 10 dB and a signal-to-noise ratio in the receiver's output of 30 dB, attenuation in a coupler from the transmission channel to the receiving channel must be greater than 46 dB. Even with relatively small attenuation spans specifications for the suppression of crosstalk are high. It is therefore necessary to take additional measures in single-fiber channels to increase the immunity of the receiver from the signal of its own transmitter. This is done by installing controlled rectifiers in the input of the receiver and output of the transmitter. It is recommended that an electrical rectifier be installed in the photodetector unit as a compromise in the absence of suitable electrooptical rectifiers. A circuit is presented illustrating implementation of this solution. A user's optical fiber communications line was developed according to the circuit suggested. It has a transmission speed of 153 Kbits/s with three pulses in a group. The photodetector's sensitivity is 57 dB·mho and a laser diode is used as a radiating element. The mean power introduced into the fiber is 17 dB·mho and the attenuation span in the fiber is 20 dB. This communications channel was compared with a 2-fiber circuit and no worsening of the subjective perception of information was observed. The proper establishment of the phase relationships of signals in the optical fiber cable is critical in an optical fiber communications line. Figures 7; references 16: 9 Russian, 7 Western (4 in translation).

[217-8831]

# LINE SECTION EQUIPMENT OF OPTICAL FIBER COMMUNICATIONS LINES FOR SPEED OF 2.048 Mbit/s

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 9 Oct 81) pp 60-65

MURADYAN, A. G., ZARKEVICH, Ye. A., MAKEYEV, O. N., USTINOV, S. A. and GRAFUTKO, B. V.

[Abstract] A description is given of the line section equipment of an optical fiber communications line which has passed bench and line tests and is now in experimental operation in urban telephone systems. The probability of error in the line section's output is not worse than  $10^{-9}$  with total attenuation of optical power on the order of 45 dB. The line section terminal and intermediate equipment is designed for setting up interexchange and intercenter connecting lines for an urban telephone system and also serves as an independent channel for transmitting digital information at a transmission speed of 2.048 Mbit/s. This equipment includes transmitting and photodetection equipment, code converters, station and intermediate optical regenerators and also auxiliary communications units, remote control units, and units for signaling and remote powering. A bipulse signal is used as the line signal, which makes it possible to minimize intersymbol interference and to eliminate problems associated with compensating fluctuations of the direct component. Some power gain is also achieved as compared with the codes used in pulse code modulation channel-forming equipment with the same noise immunity. The key elements of the line section equipment are quantum-electronic transmitting and receiving modules making it possible to convert electrical signals into optical and vice-versa and to realize complete optical matching with the optical fiber line cable and electrical matching with code conversion circuits and electronic regenerators. A laser diode is used as a radiation source in the transmitter. The radiated power from the transmitter can be monitored directly by means of a remote control system, which makes it possible to locate a malfunctioning segment of the line section. The transmitter operates at a wavelength of 0.85 micrometer and has a power requirement of not greater than 300 mA with supply voltage of 5 V  $\pm$  10 percent. A silicon pin photodiode is used in the receiver module. The photocurrent is amplified by means of a low-noise input stage with high input impedance. The receiver's sensitivity with a signal-to-noise ratio in its output of 24 dB is  $5 \cdot 10^{-7}$  W and the signal level in its output with input power of  $5 \cdot 10^{-7}$  W is 0.7 V. The receiver has a power requirement of not less than 50 mA with power supply voltage of  $\pm$  6 V  $\pm$  10 percent. A structural diagram is presented of a transmission line using IKM-30 (pulse code modulation) channel-forming equipment. The line section is made up of terminal equipment, intermediate equipment and optical fiber equipment with separable and inseparable optical connections. The operation of all components is discussed in considerable detail. Figures 7; references: 4 Russian.  
[217-8831]

## TV SIGNAL TRANSMISSION METHOD USING ADDITIONAL DIGITIZATION

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 22 Oct 80) pp 11-15

BEZRUKOV, V. N. and ZHDANOV, V. V.

[Abstract] The development of solid state memories which can store several frames has made it possible to build systems using additional signal digitization in order to expand the capacity of existing TV channels. The features and shortcomings of a number of methods are discussed, including transforming the signal into a series of samples through multiplication by a periodic function  $F_1(t)$ , alternating the signals carrying separate programs in groups of signal elements, approximating the TV signals using Taylor's formula for a function of several variables, serial transmission methods with the orientation and form of the samples depending upon the information properties of the TV signals, and methods in which the components of Taylor's formula are transmitted directly. These methods can be used to multiplex several black and white or color programs over a single channel, or to reduce the bandwidth of a single channel. In both cases a substantial increase is achieved in the utilization of existing channels, while retaining good transmission quality. References 10: 8 Russian, 1 Western and 1 Japanese in translation.  
[237-6508]

## STRUCTURE OF AUTOMATED TELEVISION TRANSMISSION NETWORK

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 16 Jun 81) pp 6-10

DERYUGIN, N. G.

[Abstract] Automated television transmission networks are based on automated TV transmission stations, automated TV relays which receive their signal via radio or cable and automated radio broadcast stations which operate unattended. Automated TV networks are structured along administrative and territorial lines, with some central facilities being manned by highly qualified personnel and other centers being controlled remotely. Remote controlled stations are equipped with a full range of monitoring gear. Of particular importance is the introduction of remote control and quality control for transmission facilities located in remote regions, and providing automated TV transmission sectors in areas with low population density. An experimental remote controlled network has been put into operation in Volgogradskaya Oblast'. Figures 4; references: 2 Russian.  
[237-6508]

## TRANSMISSION OF ANALOG SIGNALS THROUGH OPTICAL FIBER COMMUNICATIONS LINES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 1 Oct 81) pp 52-54

KALMYKOV, I. V., KUDRYASHOV, O. V., LOMANOV, V. G., PAK, G. T.,  
PROKHOROV, A. M., SISAKYAN, I. N., STEL'MAKH, M. F. and SHVEYKIN, V. I.

[Abstract] A description is given of an experimental example of the transmission of a SECAM color television signal created at the Physics Institute, USSR Academy of Sciences, as an example of the possibility of creating systems for the transmission of analog signals through optical fiber communications lines. From the TV transmitter a video signal with a spectrum width of 6 MHz and a frequency-modulated audio subcarrier with a center frequency of 6.5 MHz are fed through a mixer to a pumping amplifier which modulates the intensity of the radiation. The radiation is introduced into a light conductor by means of an optical connector. At the receiving end the signal is picked up by a photodetector and is fed through a receiving amplifier to a video amplifier and the audio subcarrier is fed through a band filter with a center frequency of 6.5 MHz to the TV receiver's audio intermediate-frequency amplifier. The receiving amplifier is constructed from series 175 integrated microcircuits. A 1NT251 transistor matrix is used for the pumping amplifier. Two forms of radiators were used as radiation sources in the model: a continuous injection heterolaser and a GaAs light-emitting diode. The first experimental models of continuous heterolasers based on the AlAs-GaAs system have been created by industry and have a minimum mean time between failures of not less than  $10^4$  h and a 90-percent service life of not less than 20,000 h. The injection heterolaser used in the model is based on a heterostructure of the  $n\text{Al}_{0.35}\text{Ga}_{0.65}\text{As-pAl}_{0.07}\text{Ga}_{0.13}\text{As-pAl}_{0.35}\text{-Ga}_{0.65}\text{As}$  type grown on a gallium arsenide substrate doped with silicon and having dislocation density of not greater than  $10^3 \text{ cm}^{-2}$ . Design-wise the heterolaser's active element is in the form of a small mesa with overall dimensions of 250 X 100 X 400 micrometers. High-frequency channels are suppressed because of the insufficient speed of response of the photodetector used. It is concluded that with the element base mastered by industry it is possible at this time to create systems for the analog transmission of TV signals with a frequency up to 50 MHz. Figures 5; references 4: 3 Russian, 1 Western.

[217-3831]

## SINGLE-MODE FIBER LIGHT GUIDES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 5 Nov 81) pp 23-26

GRIGOR'YANTS, V. V., ZHABOTINSKIY, M. Ye., DETINICH, V. A.,  
ZAMYATIN, A. A., IVANOV, G. A., KORENEVA, N. A. and MERTSALOV, S. A.

[Abstract] A technology is described for fabricating single-mode fiber light guides with low attenuation and high birefringence on account of the formation of an asymmetric borosilicate sheath. It has been demonstrated experimentally that these light guides maintain well the polarization of the transmitted light and are suitable for use in optical fiber interferometers. Since the doping impurity which causes the greatest birefringence in single-mode fiber light guides is boron, a light-reflecting borosilicate sheath is formed by the deposition of glass 600 to 800 microns thick with combined oxidation of  $\text{SiCl}_4$  and  $\text{BBr}_3$ . The UIZS-1 automated unit is used for this purpose. The light-conducting layer is formed by the deposition of a thin layer of pure quartz glass, as the most optimum procedure. In depositing a thin layer of  $\text{SiO}_2$  the rate of admission of  $\text{SiCl}_4$  is reduced and the total flow of oxygen is increased to 90 to 100 liters/h and a gas stream divider is employed, making it possible to feed about 1/4 of the vapor-gas mixture into the support tube. For the purpose of forming an elliptical light-reflecting sheath the stock is ground on two opposite sides until the light-reflecting sheath is exposed and then it is pulled. As the result of surface tension the fiber is rounded on the outside and the sheath becomes ellipsoidal. A method has also been developed for fabricating light guide stock in which the "figured" light-reflecting sheath is formed directly in the process of fabricating the stock for a light guide with a round cross section. The difference between the refractive indexes of the core and sheath usually equals  $(4 \text{ to } 6) \cdot 10^{-3}$  and the outside diameter of samples of single-mode fiber light guides is in the range of 100 to 120 micrometer with a core diameter of 4 to 7 micrometer. Light guides with a cutoff wavelength of 0.63 micron and 0.85 to 0.9 micron have been made. Experimental apparatus is described which is used for studying the polarization properties of single-mode fiber light guides. It utilizes an He-Ne laser as a light source and a quarter-wave plate and polarizer for producing light with the required direction of linear polarization. A polarizer or Wollaston polarizing prism spatially separating components with orthogonal polarization is used as an analyzer for the polarization state of the output radiation and silicon photodiodes are used as photodetectors. An electronic circuit makes it possible to determine the degree of polarization and a magnetic field is created which modulates the state of polarization at the point of its application. Figures 7; references 14: 1 Russian, 13 Western. [217-8831]

## LOSSES IN MICROBENDS IN OPTICAL FIBERS OF GLASS-POLYMER TYPE WITH LOOSELY FITTING ABSORBING SHEATH

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 9 Nov 81) pp 18-23

FEL'D, S. Ya.

[Abstract] Fiber light guides with a glass light-conducting core and a polymer light-reflecting sheath are widely used in communications lines of relatively short length. A theoretical discussion is presented of the mechanism of losses in microbends in light guides of this type and estimates are made of additional losses caused by the influence of nonideality of the material of the light-reflecting sheath. Effects originating with the existence of a gap between the core and polymer sheath are also discussed. A study is made of the statistical characteristics of irregularities occurring in glass-polymer light guides. Light guides with both a tight and loose arrangement of the core in the sheath with an asymmetric gap are discussed. The propagation of radiation is discussed in an irregular light guide formed from a glass core with a round cross section with a diameter of  $2a$  and a refractive index of  $n_1$ , surrounded, tightly or with a gap, by a polymer sheath with a refractive index of  $n_2$ , whose thickness is sufficient for the effective reflection of rays propagated at grazing angles,  $\alpha$ , less than the critical. Losses in the material of the core are assumed to be negligibly small. For studying losses in microbends a differential equation is employed which describes the diffusion of rays in terms of angle  $\alpha$  in an irregular light guide with a stepped refractive index profile. In order to take into account the influence of losses in the sheath's material a term is added to this equation which takes into account the presence of differential mode attenuation in a regular light guide, i.e., describing the reduction in the number of rays with angle  $\alpha$  as the result of absorption in the sheath. An equation is derived which takes into account the unknown attenuation factor,  $\sigma$ , of the so-called statistical mode. It is demonstrated that it is possible to estimate from the results of measuring losses in microbends in a glass polymer light guide of the usual design, i.e., with no gap, the possible reduction in losses in microbends when a gap is created between the core and sheath. Calculated relationships are obtained between losses in microbends and a parameter describing the statistical properties of irregularities and a parameter characterizing losses in the material of the sheath. A determination is made of with what relationships between experimentally determined values of losses in microbends and losses in the sheath's material the thermal component of microbend losses is important. It is demonstrated that by measuring losses in microbends it is possible to determine the statistical distribution of microbends. Figures 3; references 13: 4 Russian, 9 Western.  
[217-8831]



## AUTOMATION OF ALIGNMENT OF FIBER OPTIC ELEMENTS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 1 Oct 81) pp 47-48

ANDREYKO, A. V., KALMYKOV, I. V., KLEPIKOVA, N. L., KUKLIN, G. N.,  
LOMANOV, V. G., SIMACHEV, N. D. and SISAKYAN, I. N.

[Abstract] The technical parameters of optical fiber communications lines depend considerably on the precision of the operation of aligning various fiber and integrated optic elements in relation to the optical axis when interconnecting them. This process is highly labor intensive and it is therefore desirable to automate it. A description is given of a model of an automated system developed at the Physics Institute, USSR Academy of Sciences, using a minicomputer for controlling linear and angular manipulations. The system is designed in accord with the CAMAC standard and consists of a video terminal, an "Elektronika-60" minicomputer with a 4K-word memory, a crate with CAMAC modules and an aligning unit. The crate includes a scaler, an analog-digital converter, a step motor control module, a voltage conversion module, a controller, and a commutator for selecting the appropriate step motor. The aligning unit is based on a 5-coordinate table making movement possible along two horizontal coordinates, X and Y, and axial coordinate, Z, and two angular coordinates. The linear coordinate resolution is 1 micrometer and the angular 1.5 seconds of arc. The position of one element to be combined is fixed and the other element, e.g., a fiber light guide, is fastened to the 5-coordinate table whose position is controlled by the minicomputer. Movement takes place in the direction of an increase in power in an output photodetector. An alignment algorithm is presented which makes it possible to eliminate situations such as non-optimum positioning and recycling. This algorithm takes into account the relative position of coordinates. Information on the optical power is entered into the minicomputer in the form of a code produced by means of the analog-digital converter and the computer compares the data obtained with the old data and issues a control signal to the step motor control module. The punched tape alignment program is input into the minicomputer by means of a photoelectric reader. Figures 3.

[217-8831]

## STUDY OF INTERMODE DISPERSION IN OPTICAL FIBERS BY CORRELATIONAL ANALYSIS OF RADIATION FIELD

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 3 Dec 80) pp 220-232

DEDLOVSKIY, M. M., KORSHUNOV, I. P., MATVEYEV, R. F. and  
TUTUBALIN, V. N.

[Abstract] In continuation of studies of the performance of multimode optical fibers, measurements were made of intermode dispersion and the results are now evaluated by the method of correlation analysis. A gas laser served as a light source in the experiment with an autocorrelation function, periodic in time its radiation field constituting a superposition of fiber modes and the autocorrelation functions of all modes at the fiber exit similar to the correlation function at the entrance, but shifted from one another by time intervals proportional to their respective time lags. The equipment included, in addition to a fiber-optics interferometer and a Ne-He laser operating in the TEM<sub>00</sub>-mode, three light-splitting mirrors, a plane-parallel plate, a microobjective, three objectives, a plane fixed mirror, a plane sliding mirror, a quarter-wave plate, a polarization analyzer, a photo-receiver, a diaphragm, a buffer amplifier, a constant-component filter, a selective amplifier with square-law detector, and an XY-plotter. In the theoretical part a relation is established between the luminosity function and the amplitude-frequency characteristic of a multimode fiber, assuming the amplitude-frequency characteristic to be determined by intermode dispersion only. The field intensity distributions over the cross section of the reference beam and over the fiber exit section as well as the luminosity function of the interference pattern are first assumed to be known at each point of the fiber section and then treated probabilistically on the basis of random distributions. The results are applied to a two-layer fiber, specifically the 800 mm long GRADAN multimode fiber actually tested. The authors thank V. V. Grigor'yants and G. A. Ivanov for supplying the fiber specimens, Ye. N. Korshunova and T. V. Selezneva for calculating the pulse response, B. G. Klevitskiy for assisting with measurements, also V. P. Vard'ye and A. D. Shatrov for helpful discussions and valuable suggestions. Figures 5; references 11: 7 Russian, 4 Western. [199-2415]

## COMPONENTS OF OPTICAL FIBER COMMUNICATIONS LINES

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 27 Oct 81) pp 10-18

STEL'MAKH, M. F.

[Abstract] The state of the development and manufacture of the key components of optical fiber communications lines is discussed, including radiators, receivers, transmitting and receiving modules and integrated optical devices. The present stage of the development of optical fiber communications lines is characterized by the development of components for the short-wave and longwave bands, i.e., 0.8 to 0.9 micrometer and 1.1 to 1.7 micrometer. Existing radiators based on ternary solid solutions of the (AlGa)As type operating in the 0.8 to 0.9 micrometer band and silicon receivers utilizing pin diodes do not conform to the optimum wavelengths for a quartz optical fiber with regard to minimum dispersion and attenuation. The main development work on various types of optical fiber communications lines is being done with components for the shortwave band, because the technology for this band is better developed. These components are used in relatively short lines, such as in intrasystem and local communications lines. Soviet scientists were the first to demonstrate that radiation sources for the longwave band can be created from 4-component solid solutions of the InGaAsP type, and receivers using structures of the InGaAsSb type have been created for this band. The problem of obtaining high-quality materials and structures is still being faced in this case, however. Semiconductor radiation sources utilizing heterostructures are the most widely used at the present time in optical fiber communications lines. The three basic types are discussed: light-emitting diodes, superluminescent radiators and semiconductor lasers. A so-called superluminescent diode has been developed for optical communications purposes, based on a laser heterostructure in the AlAs-GaAs system. The greatest achievement in recent years in the area of semiconductor lasers for the shortwave band has been the development of lasers with a minimum mean time between failures of 10,000 h. The main trend in improving the fundamental characteristics of semiconductor lasers has been to reduce the size of the laser's active region. The optical fiber used at the present time has minimum attenuation and dispersion in the 1.1 to 1.7 micrometer waveband and lasers have been produced for this band by employing double heterostructures in which the emitters are made of indium phosphide and the active region of the quaternary solution InGaAsP. Silicon-based avalanche photodiodes and pin photodiodes satisfy the requirements for photodetectors in the 0.8 to 0.9 micrometer band. Development work is under way on injection lasers with distributed Bragg reflectors, semiconductor lasers with an external resonator and aluminum-yttrium garnet lasers with neodymium and light-emitting diode pumping. Work on the integration of optoelectronic devices is being done along three major lines: the creation of monolithic integrated circuits employing semiconductor substrates, such as a laser-modulator, laser-transistor, laser-photodetector; the creation of

monolithic integrated circuits utilizing ferroelectric substrates, such as an electrooptical directional coupler and a modulator with a lithium niobate interferometer; and the creation of hybrid integrated circuits employing "support" substrates. Figures 12; references 18: 13 Russian, 5 Western. [217-8831]

UDC 681.84.083.55

#### OPTICAL SYSTEMS FOR RECORDING AND REPRODUCING VIDEO DATA

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 21 Sep 81) pp 9-17

TAKEDA, Ya.

[Abstract] The two existing methods of recording and reproducing two-dimensional video data with a laser beam, directly by sequential in time coding of FM signals and holographically by sequential recording of image frames, are reviewed and compared. Both methods involve a tradeoff to ensure a sufficiently high signal-to-noise ratio without excessive complexity of the tracking system. The state of the art includes use of rotating video disks with a helium-neon laser or less costly laser diodes. Second-generation and third-generation equipment includes cyclic memories with erasure and transcription. Latest trends in thermomagnetic recording and optical counting on film as well as in film materials and technology are already set for the coming decade. Figures 15; references: 26 Western. [203-2415]

UDC 681.786.2

#### INSTRUMENT FOR DETERMINING POINT OF DAMAGE IN OPTICAL FIBER CABLE WITH DIGITAL READOUT OF DISTANCE

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 9 Oct 81) pp 87-90

OLEYNIKOV, A. D., PERSHAKOV, V. V., ROMANOV, V. S. and SKLYAROV, O. K.

[Abstract] A description is given of an instrument employing the pulse method of location and designed for determining the point of damage in an optical cable during its production, installation and use in communications lines. This is a portable bench-type instrument. An oscillograph can be connected to it for observing the full pattern of reflections in the optical fiber cable, which makes it possible to make general estimates of the cable's quality. A quartz oscillator generates 1-MHz sinusoidal voltage and forms from it square pulses which are fed to two channels: a 1 : 100 divider and a normally closed electronic switch. From the 1 : 100 divider the pulses

are sent to an open switch, after which they are sent to a modulator and a controlled delay unit. Pulses 10 ns long, amplified and shaped by the modulator, modulate a semiconductor oscillator which generates short light pulses which are fed through an optical splitter to the input of the optical cable being studied. The optical signal passes through the optical cable to the point of damage and is reflected from it and returns to the optical splitter and enters a photodetector in which the light pulses are converted into electrical signals, are amplified and fed to one of the inputs of a coincidence circuit. Pulses delayed by the controlled delay line enter the other input of the coincidence circuit and a light-emitting diode in the coincidence readout circuit lights up when the pulses arriving at the coincidence circuit's inputs coincide. The operator then opens a third normally closed switch and the signal travels from the coincidence circuit to the modulator and controlled delay unit and the signal is recycled with a cycle strictly related to the distance to the point of damage in the optical cable. Time measuring units then begin to count the pulses from the quartz oscillator and the recycling cycles. After the result is read out for a time sufficient for the operator to read it, the units are automatically switched back to the original state and the measuring process is repeated. The accuracy of measuring a point of damage in a cable up to 1 km long is  $\pm 1$  m and the instrument's overall dimensions are 480 X 300 X 150 mm and it weighs about 10 kg. Figures 4.

[217-8831]

#### OPERATING FEATURES OF 'IL'MEN' TELEVISION RADIO STATION

Moscow VESTNIK SVYAZI in Russian No 2, Feb 82 pp 29-32

SHAPKOV, F. N., senior engineer, Rezekne Radio-Television Transmitting Station, and KIRILLOV, N. G., senior engineer

[Abstract] The first of the new series "Il'men" band-IV television radio station has operated in Rezekne (LaSSR) since 1979 and has already accumulated 12,000 h transmitting time. Its main distinguishing features are transit-time klystrons in the output stages, signal modulation at intermediate frequency, high levels of transistorization and automation. Klystron amplifiers in both video channel and audio channel are preferable to traveling-wave tubes because of their better performance characteristics, particularly wider range of linearity. Appropriate measures have been taken in order to ensure adequate stability of these devices and adequate reliability of other critical station components such as high-frequency commutation, power compounding, phasing and demodulation. Major deficiencies were found to be poor soldered joints in the low-power stages and excessive heating inside equipment cabinets. Weak spots were also found in the power supply equipment and antenna-feeder equipment. Tubular feeders (160 mm diameter) have been replaced with VAKhA 75-120D cables (imports). The station complex includes now also "Yakhont-A" test and measuring equipment for inspection of picture and sound tracks. However, the station still needs more alternate

and standby capacity. Nevertheless, after corrections and adjustments have been made the station has already been operating reliably for 1050 h. Figures 3; tables 1.  
[198-2415]

UDC 391.6 : 535.8 : 666.189.2

#### CREATING OPTICAL CONNECTORS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 2, Feb 82  
(manuscript received 7 Sep 81) pp 50-52

MAKOVETS, G. K. and POKROVSKIY, V. R.

[Abstract] The practical introduction of optical fiber data transmission lines has been impeded by the lack of the mass production of optical connectors. Optical connectors for broad industrial applications must meet the following key requirements: They must not have to be aligned when in use; they must have low attenuation of less than 0.5 to 1 dB; they must not require complicated equipment for installing them on cables; and the cable termination must be strong in order to ensure reliable performance and protection of the glass fiber. The designs of connectors most often used in Soviet optical fiber data transmission lines represent a compromise engineering solution, whereby the connector cannot be aligned when in use but is aligned when terminating the cable. This makes it possible to eliminate deviation in the geometrical parameters of single fibers and the error associated with the tolerance for machining parts of the connector. An illustration is given of an optical connector developed for connecting segments of single-fiber cables with a 60-micron diameter of the fiber's light-conducting cross section. This connector is in the form of a sleeve with grips at its ends. The inside surface of the sleeve, 5 to 6 mm long, has a 3- to 5-micrometer high-precision finish. The cable lugs are in the form of sleeves on which thrust collars have been fitted. The sleeve and collars are made of steel in order to increase wear resistance in repeated connection and disconnection. The lugs are tightened by means of collet nuts when the connection is made. When terminating the cable, the face end of the lug is ground and polished and cross-shaped alignment marks are made on it by means of a special micro marking gauge with a distance of 50 micrometers between the marks. Perpendicularity is made possible by a special collet clamp. The prepared end of the cable is inserted into the lug which has first been filled with an epoxy compound, so that the end of the fiber projects 0.5 mm from the opening. The lug is then inserted into the hole of the table of the unit for terminating the cable and is fixed with a clamp. A transparent film is placed on the projecting end of the single fiber perpendicular to the axis of the fiber and by moving the film under a microscope over the alignment marks it is possible to align the single fiber coaxially with the lug. The face end of the lug is ground and polished after the epoxy compound hardens. This termination process makes it possible to

align the fiber's axis with accuracy of 4 to 7 micrometers. The process of inserting the lug has been simplified. The fiber is inserted without centering and the resulting eccentricity is eliminated by final machining of the outside cylindrical surface of the thrust collar on the terminated cable. The terminated end of the cable is inserted into the clamp of a unit with a rotating cutter whose axis of rotation is in line with the axis of the light-conducting cross section of the fiber. Then the external cylindrical surface of the collar is machined by means of the cutter. This technique makes it possible to lower specifications for the precision of the fabrication of individual units and parts and eliminates the influence of eccentricity of the light-conducting core relative to the outside surface of the single fiber. Figures 2.

[217-8831]

UDC 621.396.662.072.6.078

STATISTICAL ANALYSIS OF DIGITAL FIRST-ORDER PHASE-LOCKING SYSTEM WITH  
NONUNIFORM REGULATION INTERVAL

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 27 Oct 80) pp 278-286

SHAKHGIL'DYAN, V. V., BURDZEYKO, B. P. and AKIMOV, V. N.

[Abstract] Digital first-order automatic frequency trimming systems with phase control and constant or variable regulation interval are analyzed statistically on the basis of recurrence relations for a structure consisting of a reference generator with adder-subtractor and frequency divider. The phase detector in the control loop is assumed to have a relay characteristic, at its second input a rectangular signal mixed with additive noise is assumed to appear, and the digital low-pass filter in series with it is disregarded here. Nonuniformity of the regulation interval is taken into account by not assuming a very large frequency divisor. Certain properties of applicable Markov chains are revealed by this analysis and are demonstrated on numerical examples. Asymptotic distributions are obtained for the case of a nonzero initial frequency mismatch. The conditions of pullout are determined according to the model of random walk along a circle. The authors thank M. A. Mironov for interest in this study and discussion of its results. Figures 4; references 10: 9 Russian, 1 Western.

[199-2415]

AUTOMATIC TRACKING DISTORTION CORRECTOR WITH REFLECTION OF DIGITAL TV  
CHANNEL FREQUENCY CHARACTERISTICS

Moscow TEKNIKA KINO I TELEVIDENIYA in Russian No 12, Dec 81 pp 41-43

RADIKAYNEN, Ya. I.

[Abstract] In 1980 the author described an automatic tracking corrector of TV channels, which transmits analogous signals. In the present work he considers the circuit of an automatic tracking corrector for a digital TV channel. A block diagram of the device is presented and its operation in a correction mode with reflection of the frequency characteristic is described. The rate of convergence of the algorithm of the device is determined. Figures 3; references: 3 Russian.

[159-6415]

UDC 778.41

EFFECT OF THREE DIMENSIONALITY DURING OBSERVATION OF TWO-DIMENSIONAL  
IMAGES

Moscow TEKNIKA KINO I TELEVIDENIYA in Russian No 12, Dec 81 pp 49-51

DUKLAU, V. V., KOPYLOV, P. M., POLYANSKIY, Yu. G. and UKRAINSKIY, O. V.,  
Leningrad Electrical Engineering Communications Institute

[Abstract] It is shown that: 1) Monocular vision can be used for obtaining depth of TV images. However, comfort in observing the images is insufficient; 2) During observation of moving images, an appreciable stereo effect can be obtained with binocular observation of plane TV images if their brightness is considerably reduced for one eye; 3) It is possible to obtain the illusion of three dimensionality during observation of static plane images if their linear dimensions for both eyes differ by 10-20%; 4) In order to obtain the illusion of three dimensionality during observation of stationary and moving plane TV images, simultaneous realization of the conditions stated in point 2 and 3 above is recommended; and 5) In some stereoscopic TV systems with insufficient depth of relief, a decrease of brightness of one of the images of the stereo pair can also be used.

Figures 3; references 7: 5 Russian, 2 Western.

[159-6415]



ADAPTIVE RECURSIVE FILTER FOR COMPLEX SIGNALS

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 46, Dec 81 p 283-284

[Translation of Patent number 890544]

[Text] An adaptive recursive device for filtering complex signals is disclosed which contains two channels, one equiphase and the other quadrature, each of which consists of a filter consisting of a multitap delay line with taps connected to the inputs of four groups of weighting blocks, with the control input of each weighting block of the first group of the filter of the equiphase channel combined with the control input of the corresponding weighting block of the first group of the quadrature-channel filter and connected through a corresponding first-group accumulator to the output of the first-group summator, the first input of which is connected to the output of the first-group multiplier of the equiphase-channel filter and the second input of which is connected to the output of the first-group multiplier of the quadrature-channel filter; the control input of each weighting unit of the second group of the equiphase-channel filter is combined with the control input of the corresponding second-group weighting unit of the quadrature-channel filter and connected through the corresponding second-group accumulator to the output of the second-group summator, the first input of which is connected to the output of the second-group multiplier of the equiphase-channel filter and the second input of which is connected to the output of the second-group multiplier of the quadrature-channel filter; the outputs of the first-group weighting units in each filter are connected to the first input of the output summator of the corresponding channel, the second input of which is connected to the outputs of the second-group weighting units of the filter in the other channel; the output of each output summator is connected to the inputs of the decision unit, the first output of which is connected to the first inputs of the first-group multipliers of the equiphase-channel filter, the second input of each of which is combined with the first input of the second-group multiplier of the equiphase-channel filter and connected to the corresponding tap of the multitap delay line of the equiphase-channel filter and to the first inputs of the second-group multipliers of the quadrature-channel filter, the second input of each of which is combined with the first input of the first-group multiplier of the quadrature-channel filter and connected to the corresponding tap of the multitap delay line of the quadrature-channel filter, and a partial derivative computer consisting of a multitap delay line to the taps of which are connected the first inputs of

the corresponding weighting units and the first inputs of the corresponding multipliers, the second input of each of which is connected to the output of the decision unit, and the output of which is connected through the corresponding summator and accumulator, in series, to the control input of the weighting unit and to the control input of the third-group weighting units of the equiphase and quadrature channel filters. This filter is distinguished by the fact that in order to increase signal correction accuracy, the input of the multitap delay line in the filter of each channel is connected to an input summator, the second input of which is connected to the outputs of the third-group weighting units of the filter of its own channel, and the third input is connected to the outputs of the fourth-group weighting units of the filter of the other channel; connected between the outputs of the weighting unit and the input of the multitap delay line in each partial derivative computer is a first auxiliary summator, the other input of which is connected to the output of the output summator of the corresponding filter, to the output of which are connected, in series, the second auxiliary summator and auxiliary multitap delay line, to the taps of which are connected the corresponding auxiliary weighting units, whose outputs are connected to the second input of the second auxiliary summator, and one of the inputs of the corresponding auxiliary multipliers, the other inputs of which are connected to the second output of the decision unit; connected to the outputs of the auxiliary multipliers of the partial derivative computers of both channels are the corresponding auxiliary summator and accumulator, in series, the output of which is connected to the control inputs of the corresponding auxiliary weighting unit and to the control inputs of the corresponding fourth-group weighting units of the equiphase and quadrature channel filters.

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CSO: 1860/220

UDC 543.46

BASIC EQUATION OF ELLIPSOMETRY FOR TEST DIFFRACTION GRATINGS APPLICABLE  
DURING CHECKING OF LARGE INTEGRATED CIRCUIT STRUCTURES

Moscow MIKROELEKTRONIKA in Russian Vol 10, No 6, Nov-Dec 81  
(manuscript received 9 Jul 81) pp 537-542

LONSKIY, E. S.

[Abstract] The present work determines the parameters of large integrated circuit structures by means of an investigation of the elements of a test unit in the form of diffraction gratings. The gratings were produced on a  $\text{SiO}_2$ -Si structure by means of etching into the  $\text{SiO}_2$  of periodically alternating grooves with a period  $d$  and a width  $b$  (nonetched bands have a width  $a$ ). An equivalent model is used of a plane grating which provides superposition of five gratings with a period  $d$ . The coefficients of light are shown for the five gratings. The basic equation of ellipsometry is obtained for the equivalent model, and the errors of the approximation used are analyzed. An equation is derived in order to determine for arbitrary gratings of thickness of the residual oxide in the groove and the ratio of the dimensions of the lines of the grating to its period with the aid of measurements made in five random orders of diffraction of the ellipsometric parameters  $\Delta$ ,  $\psi$  of light reflected from the gratings investigated.

References 2: 1 Russian, 1 Western in translation.

[137-A-6415]

UDC: 621.372.54.037.372

METHOD FOR SYNTHESIZING DIGITAL FILTER-DEMODULATORS BASED ON DUAL FFT

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 5 Aug 80) pp 45-47

VITYAZEY, V. V. and STEPASHKIN, A. I.

[Abstract] The simulation method is based essentially on sequential filtering and demodulation (in the sense of extracting the complex envelope with respect to the center frequency) of one segment of the partial group signal, followed by frequency separation and demodulation of another segment of the components of the complex envelope of the IDH partial group signal at a lower digitization frequency. A functional diagram of the digital filter-demodulator is presented, along with a description of the actual implementation of such a device. Using a two-stage structure for a set of narrow band filter-demodulators reduces the size of the data files input to the rapid Fourier transform processors, which is a major factor in implementing the devices using special large scale integration. These filter-demodulators can be used in developing transmultiplexers. References 5: 4 Russian, 1 Western in translation.  
[237-6508]

UDC: 621.372.544.029.6

SYNTHESIS OF MICROWAVE BANDPASS FILTERS WITH ZOLOTAREV CHARACTERISTICS

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 20 Mar 79) pp 47-52

[Abstract] One way to optimize filters is to design them on the basis of Zolotarev (elliptical filters) characteristics. This article describes a synthesis method based on using an equivalent ring circuit to implement a Brune section. Implementation of these circuits is described, along with an algorithm for synthesizing and tuning Zolotarev filters. Figures 4; tables 3; references 12: 3 Russian, 9 Western (3 in translation).  
[237-6508]

UDC: 621.391.3

# HYBRID MATCHED FILTERS FOR DISCRETE FREQUENCY-MODULATED SIGNALS AND THEIR NOISE TOLERANCE

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 1 Oct 79) pp 58-62

ZHAYLOOBAYEV, N.

[Abstract] This article examines a promising version of hybrid digital-analog filters which can operate effectively in the presence of random structural, pulsed and narrow-band noise. As a first approximation, the noise tolerance of processors using analog linear matched filters and processors using hybrid filters can be evaluated by the change in the signal-to-noise ratio at the output of the respective filters in the presence of signal, random noise and powerful structural, pulsed and narrow-band noise at the output of these filters. The noise tolerance of analog matched filters and hybrid filters is analyzed and compared. It is found that hybrid filters work better with powerful structural, pulsed and narrow band noise. Figures 4; references: 5 Russian.  
[237-6508]

UDC: 621.391.019.4

# USE OF INSTRUMENTS FOR DIAGNOSING CIRCUITS LOADED WITH WHITE NOISE IN ADJUSTING TRANSMISSION SYSTEMS

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 28 Apr 80) pp 16-20

ROMBRO, V. S., OYSGEL'T, M. G. and SHKOL'NIKOV, M. B.

[Abstract] This article describes the use of white noise signals in order to find the cause and location of reduced noise protection of transmitted signals during adjustment of a signal path. The method is explained using the example of measurements made on an actual circuit by successively shortening the length of the section tested until the problem is found. Figures 7; references: 5 Russian.  
[237-6508]

## EFFECT OF NONLINEARITY OF SIGNAL PROCESSING ALGORITHMS ON STATISTICAL CHARACTERISTICS OF ADAPTIVE FILTERS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 25, No 2, Feb 82 (manuscript received 8 Jan 81) pp 211-217

MEDVEDEV, S. Yu. and POZUMENTOV, I. Ye., Gor'kiy State University

[Abstract] A stochastic differential equation is derived for the identification error made by an adaptive signal processing filter. This equation serves as the basis for a comparative analysis of the filter performance according to a linear algorithm and a nonlinear algorithm respectively. The linear algorithm is applied to typical cases of Markov fluctuations, namely Gaussian and telegraphic ones, of the amplitude of a narrow-band random input process. The nonlinear algorithm is applied to Gaussian fluctuations with a zero mean and exponential correlation functions. The statistical characteristics, namely power of the error signal and weight-factor adaptation time as well as probability parameters of the signal amplitude, indicate a faster and more accurate filter adaptation but also a larger dispersion of weight-factor fluctuations with the nonlinear algorithm. The authors thank A. N. Malakhov for his attention and A. A. Mal'tsev for his helpful comments. Figures 1; tables 1; references 12: 5 Russian, 7 Western.  
[201-2415]

## COMMUNICATIONS

### USE OF 'KONTEYNER' RADIO RELAY LINK IN REGIONAL NETWORK

Moscow VESTNIK SVYAZI in Russian No 11, Nov 81 pp 30-31

[Article by P. M. Medyanik, chief of State Inspectorate of Electrical Communications of Checheno-Ingushskaya ASSR PTUS]

[Text] The least reliable link in the Unified Automated Communications System today are the rural regional networks, where only one type of communications facility is used on many links (cable or overhead line). The reliability of an overhead line depends on the level of protection against mechanical damage in regions where agricultural or other excavation operations are conducted. Furthermore, the severe shortage of cable production and towers is retarding the rates of development of regional networks. Under mountainous conditions, this is aggravated by the extreme difficulty in selecting routes for cable and overhead lines.

The Production-Technical Communications Directorate (PTUS) of the Checheno-Ingushskaya ASSR began in 1976 to introduce the "Konteyner" radio relay equipment in regional networks, first as the basic type of communications, and then to increment and provide backup for existing cable or overhead lines.

Five years of experience in operating the "Konteyner" equipment under mountainous conditions have demonstrated good performance of the channels which are organized and better reliability than other types of communications.

Before this equipment began to be put in place, it was decided to concentrate the "Konteyner" within a single enterprise — the RRTPTs [expansion not given]. This made it possible to accumulate experience in operating the equipment and to train qualified specialists who know how to overcome many of the difficulties involved in setting up radio relay links and calibrating equipment under both laboratory and field conditions.

When the "Konteyner" radio relay equipment is used on intra-regional links, the interval length is between 10 and 25 km. In order to organize stable communications over such intervals, path clearance of 4-7 m is quite sufficient. This clearance can be provided with an antenna height on the order of 20-25 m. The directivity pattern of the phased antenna array used is on the order of 15-20° in both the vertical and horizontal planes. This has made it possible to use inexpensive high-voltage towers of type SK-7 of SK-4A (high voltage conical support) 26 m high,

which are not particularly rigid. The mechanical strength of this support allows it to accommodate a 1.5 x 1.5 m platform on top (of the projector variety) and an antenna support in the center which enters the "Konteyner" set. An enclosed metal ladder is fastened to the side of the tower (Figure 1).

The tubular antenna support supplied for "Konteyner" repeater stations consists of two sections: the bottom section is fastened "blind" to the support, while the top section can be rotated freely. The antennas are fastened in one direction to the top part, and in the other direction to the bottom. In order to align the antennas fastened to the fixed part we have developed a special strap and flange arrangement which, when released, allows the antenna to move freely on the bottom part of the support pipe. A second antenna is also connected to this flange.

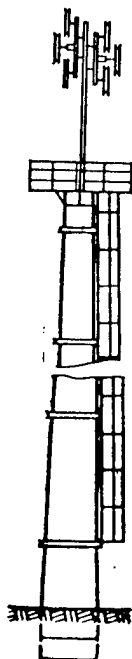


Figure 1. Construction of "Konteyner" antenna.

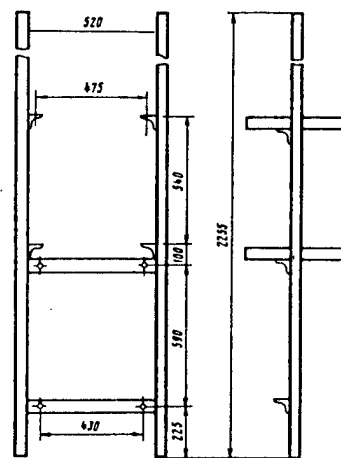


Figure 2. "Konteyner" equipment rack.

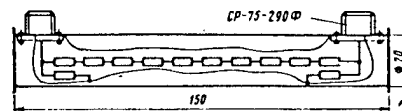


Figure 3. HF line equivalent.

The dimensions of the radio relay equipment do not correspond to the standard dimensions of line equipment room equipment; therefore, we fabricate special racks of 75 x 75 angle iron (Figure 2) which can accommodate two terminal or one intermediate "Konteyner" stations and a single type VB-24/6 rectifier for their power supply. Equipment held in this rack installed in a row with other equipment is convenient to service, and fits well in the line equipment shop.



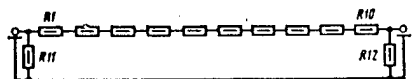
The manufacturing plant usually equips the antenna feeder cable with a high frequency connector which connects the cable perpendicularly to the front panel of the antenna filter unit, which interferes with the passage of service personnel. We have replaced this connector with an elbow. The feeder cable now runs upward and is fastened to a cable rack, from where it goes on to the antenna.

In order to align the A- and B-stations radio relay and AU multiplexing equipment under laboratory conditions, an HF line equivalent was fabricated of copper tubing 20 mm in diameter and 150 mm long (Figure 3). The tubing contains an electrical attenuation circuit of ten-megohm resistors in series. This network is soldered to type SR-75-290F connectors, 75 ohm resistors are connected in parallel to the ends of the line (Figure 4) and the network is placed inside the tubing. This equivalent has 35 dB attenuation; according to laboratory tests its traveling-wave ratio is between 0.85 and 0.90 through the 390-470 MHz range (according to the technical specifications for the "Konteyner" equipment, the traveling-wave ratio of the line must be at least 0.7).

Since the signal attenuates by 70-90 dB over the propagation path, 2 to 3 such equivalents are used for laboratory testing of radio relay equipment: these are connected directly by means of cable jumpers to the antenna connectors of both radio relay stations in one interval.

According to the technical specifications for the "Konteyner" radio equipment Zh'II.105.000/002-TU, main stations are produced only with the suffix VN (with receive frequency higher than transmit frequency). If a "Konteyner" DM-400/6 or DM-400/32 with suffix NV is already in place at the location where the radio relay equipment is being installed, the new equipment can be reconfigured for the suffix NV to ensure electromagnetic compatibility. In order to do this, it is sufficient to switch the transceivers and antenna filters on the radio relay link interval between stations A and B without any changes in the structure of the equipment, levels, etc. This limitation which the technical specifications impose on the equipment is obviously unjustified, especially since repeater and terminal stations are being produced with this suffix.

Figure 4. HF line equivalent where  
R1-R16 - 10 megohms; R11-R12 - 75 ohms.



The frequency plan of the "Konteyner" equipment allows 6 routes to be organized. Since routes I and III, II and IV have incompatible image channels at a single point, only 4 routes can be organized. If the tandem junction at an oblast center requires more routes, it is possible to install "Konteyner" equipment on any 2 routes with the same pairs of frequencies at the main stations, connecting the first trunk to one route and the second trunk to the other. However, this scheme, which provides no backup, can only be used to duplicate some other link.

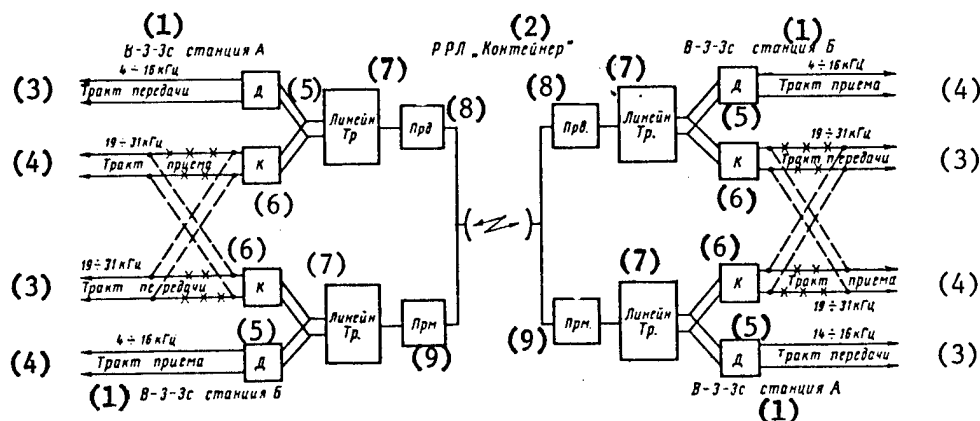


Figure 5. Connection of two V-3-3s transmission systems to a single "Konteyner" equipment trunk. Key: 1, V-3-3s station; 2, "Konteyner" radio relay link; 3, transmit circuit; 4, receive circuit; 5, [not explained]; 6, sealed reed relay; 7, line transformer; 8, transmitter; 9, receiver.

Difficulties have now arisen in the delivery of type OR-6 transmission systems: only 40% of the PTUS requirement for this equipment is being satisfied. Therefore, "Konteyner" radio relay equipment is not used at full capacity (a total of one trunk for every 6 channels) or is used without any transmission systems. In these cases, a single trunk can accommodate two type V-3-3s transmission systems, which makes it possible to obtain 6 voice grade channels (Figure 5). The psophometric noise level in the telephone channel of a two-span radio relay link multiplexed with 2 V-3-3s systems is 3 to 4 times lower than the OR-6 equipment; the cost of 4 V-3-3s racks is 5220 rubles lower than for OR-6 racks (in the version which provides 6 audio frequency channels).

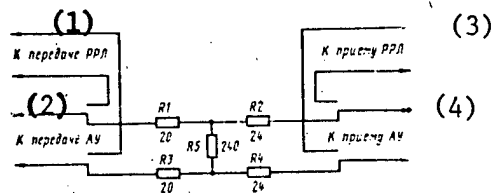
If the OR-6 multiplexing equipment is placed immediately adjacent to the ATSK [Crossbar-type telephone exchange] and the impedance of the signal channel circuit is less than 1 kilohm, current on the order of 120 to 130 mA passes through the contacts of sealed-reed relay K in the SK-2 module, which causes the contacts to stick, and sometimes causes the relay to break down. In such cases, we connect additional resistance of the order of 120-390 ohms in series with the relay contact circuit. The optimal value of this current is 70-80 mA.

In the first models of the OR-6 multiplexing rack, the VTSP [expansion not given] table from the radio relay equipment was connected "hermetically". When checking the multiplexing equipment working "into itself", the cable had to be unsoldered in order to load the equipment into an equivalent. Our rationalizers installed two switches and an attenuator on the removable cover of the OR-6 rack (Figure 6). For convenience, the knobs of these switches can be connected mechanically by a jumper, or a wafer switch can be used.

The circuit of the low-frequency amplifier unit SS in the OR-6 rack provides full-time loudspeaker communications, for which the volume control only partially reduces the volume: this disturbs the work of service personnel in the shop.

In order to eliminate this effect, a switch has been installed in low frequency amplifier module SS which turns off the loudspeaker and simultaneously loads the low frequency amplifier to a 5-ohm resistor.

Figure 6. Connection of attenuator.  
1, to radio relay transmission; 2, to multiplexing equipment transmission;  
3, to radio relay reception; 4, to multiplexing equipment reception.



On the whole, 5 years of experience in operating this equipment has demonstrated good operating qualities.

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CSO: 5500/1014

DESIGN OF OPTIMUM NONLINEAR INSTRUMENTAL FOLLOWING SYSTEM ACCORDING TO  
GENERALIZED QUALITY DIAGRAMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 24, No 11, Nov 81 (manuscript received 14 Apr 81)  
pp 17-24

ARSLANOV, R. A. and LIKHTSINDER, M. Ya., Tashkent Electrical Engineering  
Institute of Communication

[Abstract] A method is described for synthesis of nonlinear following systems, optimum with respect to speed of response, on the basis of generalized quality diagrams. A procedure for plotting a quality diagram with two adjustable parameters is considered. A choice is made of the parameters of the correcting network of the following system of an automatic compensator with a pre-amplifier. Use of the procedure described is illustrated, employing as an example a calculation of the correcting network mentioned above. In contrast to a 1977 report of which R. A. Arslanov (see above) was a coauthor in a solution of the problem of nonlinearity of the amplifier, the mechanical characteristics of the motor and the force moment of dry friction are taken into account. It is concluded: 1) Use of the method of a generalized quality diagram gives the possibility of planning complex nonlinear following systems close to optimum with respect to speed of response; 2) The results of an approximate construction of a transient process, according to a generalized quality diagram, gives a good convergence with the results of modelling. The paper was recommended by the Department (Kafedra) of Measurements in Communication Technology. Figures 4; references: 5 Russian.  
[151-6415]

UDC: 621.317:621.376.56

MODEL OF QUANTIZATION AND OVERLOAD NOISE SOURCE IN AUDIO FREQUENCY CHANNEL  
OF DIGITAL TRANSMISSION SYSTEM

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received after completion 10 Jul 80) pp 20-23

SHPIGEL', A. R. and SHCHAVINSKAYA, V. M.

[Abstract] Two noise models, one for low test signal levels and the other for higher test signal levels, are described. The first model contains a quantizer and an additive noise source, while the second model contains only a quantizer. These models allow the probability distribution functions of the instantaneous quantization and overload noise values to be examined with test signals of various types and levels, which is necessary for investigating the properties of voice grade channels in pulse-code modulation systems and for developing methods and means of measuring system characteristics. Figures 3; tables 2; references 8: 4 Russian, 4 Western in translation. [237-6508]

UDC: 621.391

IMPROVING OPERATION OF INTERCITY AUDIO BROADCAST CHANNELS

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 31 Oct 80) pp 40-42

NYURENBERG, V. A.

[Abstract] An automatic compensator for stabilizing the signal gain over intercity audio broadcast channels is described which uses the operating principle of an inertial level limiter. This compensator can be used to replace the compander system and preemphasis and recovery circuits at the receiving end of the channel, thus stabilizing the normal signal level, cutting the power at the output of the transmission system by a factor of two, providing required noise suppression and preventing overloading of subsequent sections. In the investigations, development and tests of the autocompensator, an active part was taken by coworkers of laboratories of the Scientific-Research Sector of the MEIS (Moscow Order of the Red Banner of Labor Electrical Engineering Institute of Communication) E. B. Kuznetsov, S. L. Mishenkov, A. M. Grishin, A. I. Ryazanskiy, I. M. Minayeva and K. K. Kvashnin. Much assistance was given by workers of interurban telephone stations. Figures 5; references: 5 Russian. [237-6508]

SPECTRAL-CORRELATION PROPERTIES OF SIGNAL AND NOISE MIXTURE AFTER  
NONLINEAR NARROW-BAND TRANSFORMATION

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 17 Jul 80) pp 1678-1682

GOLYANITSKIY, I. A. and MALYSHKO, V. F.

[Abstract] An investigation is made of the spectral-correlation properties of an output process and its quadrature components at the output of a unit consisting of an inertialess nonlinearity, with the characteristic  $y = g(x)$  and a band-pass filter. The filter is sufficiently wide-band so as not to distort the process in the first spectral zone and to suppress all the remaining spectral zones. Figures 3; references 11: 9 Russian, 2 Western. [88-6415]

MINIMIZATION OF MAXIMUM PEAKS OF CORRELATION FUNCTIONS OF NOISE-TYPE  
SIGNALS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 28 Aug 80) pp 1683-1688

VARAKIN, L. Ye.

[Abstract] On the basis of an expansion of noise-type signals [NTS] in terms of orthogonal functions, conditions are determined which must satisfy NTS so that their correlation functions will have the minimum possible peaks. This establishes a basis for solution of the problem of NTS minimax. The following items are considered in the work: 1) Expansion of NTS in terms of orthogonal functions; 2) Correlation functions of NTS; 3) Probability density of correlation functions of NTS; and 4) Minimization of maximum peaks of correlation functions of NTS. It is shown that the minimum peaks of the correlation functions also possess NTS, the coefficient of expansion of which is close to optimum. The system of orthogonal functions in terms of which the expansion is carried out possesses a minimum coefficient of excess. Synthesis of individual NTS, as with a system of NTS with good correlation properties (minimum peaks), amounts to the choice of a system of orthogonal functions with a minimum coefficient of excess. It also leads to the construction of NTS in the form of a series in terms of these functions with an optimum coefficient of expansion. References: 4 Russian. [88-6415]

## PECULIARITIES OF ESTIMATING NONINFORMATIVE PARAMETERS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 28 Jul 81) pp 46-48

SHCHERBAKOV, V. Yu.

[Abstract] Problems in synthesis of algorithms for point estimation of interfering parameters are associated specifically with two peculiar features of such an estimation, namely limited importance of the cost function of estimation errors and indeterminacy during measurement of such parameters. Estimation of interfering parameters is necessary for improvement of the decision rule in testing two alternative hypotheses about the informative parameter. Here minimization of the cost function and optimization of the measuring device are considered in the practical cases of error cost function in each hypothesis independent of the interfering parameter and its estimate, quadratic cost function in signal-absent hypothesis and two-thirds-power cost function in signal-present hypothesis, interfering parameter unknown, and probability density function of interfering parameter dependent on this parameter. These examples illustrate the expediency of including decisions of the hypothesis tester in the estimation algorithm. It is also worthwhile to include accumulation of estimates. The peculiarities of estimating an interfering parameter thus make it necessary to modify not only the structure of the estimation functional but in some cases also the method of measuring such a parameter. Figures 1; references 4: 3 Russian, 1 Western.  
[203-2415]

## OPTIMUM RECURRENT EVALUATION OF AMPLITUDE OF KEYED RADIOTELEGRAPH SIGNAL IN CHANNEL WITH VARIABLE PARAMETERS AND FLUCTUATING NOISE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 18 Apr 80) pp 1644-1653

SHAROV, A. N., GROSHIKOV, Ye. N. and KOVESHNIKOV, V. G.

[Abstract] The problem is solved of a synthesis, optimum with respect to the minimum, of the mean square error of an analyzer of the quality of a radio channel. An algorithm is based on the calculation of a recurrent unbiased evaluation of the amplitude of a frequency-shift keying of a signal at the output of a communication channel which approximates a combined Markovian process with known correlation properties. The process contains a discrete (key sequence) component and continuous (change of the gain factor of the channel) components. It is assumed that in the information channel, interference operates of the fluctuating white noise type. This assumption

is permissible if as optimum working frequencies, frequencies are selected free from high-power noise with a concentrated spectrum. Methods from the theory of optimum linear filtration in state space are used for solution of the problem, assuming knowledge of the correlation properties of the signal at the output of the radio channel. The dependence is investigated of the precision of evaluation on the interval of observation, the telegraphing role and the correlation properties of the communication channel. Figures 4; references: 10 Russian. [88-6415]

UDC 621.391.:510.53

#### PHASE DETERMINATION OF PSEUDORANDOM SEQUENCES IN SEGMENT WITH ASSISTANCE OF FAST TRANSFORMS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 26 Jun 80) pp 1666-1671

LOSEV, V. V. and DVORNIKOV, V. D.

[Abstract] In many applications connected with synchronization, the problem arises of determining the phase of a pseudorandom sequence with respect to its distorted segment. The present paper considers a number of complete optimum algorithms which implement the method of maximum probability. The general characteristic of these algorithms is the effective organization of the calculating process. This makes it possible substantially to reduce the number of elementary operations required for detection of a signal. The following items are discussed in the work: 1) Determination of phase with absence of target indication; 2) Comparison of algorithms, and 3) Determination of phase with presence of target indication. The authors conclude that the algorithms described take into account all, or almost all, of the redundancy of the matrix of reference signals. They make it possible substantially to increase the efficiency of the calculation process. All the algorithms have an identical noise immunity and completely use the correcting properties of the signal. However, they differ in the speed of response, the storage capacity of a memory or the complexity of a program, during which these differences have an exchange nature. References: 2 Russian. [88-6415]



UDC: 621.395.97

MEASURES FOR IMPROVING OPERATION OF INTERCITY AUDIO BROADCAST CHANNELS

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 6 May 80) pp 43-44

SHISHKINA, N. N.

[Abstract] This article describes the testing of the tolerances of audio-frequency broadcast channels, including use of devices for testing amplitude-frequency characteristics, harmonic coefficient, gain and psophometric noise voltage during transmission pauses exceeding 1 second. The electrical parameters of channels carried by AV-2/3 equipment have been demonstrated to be sufficiently stable. It is pointed out that basic operating processes must be automated in order to improve network reliability, and that automation requires the creation of a network of reserve audio broadcast channels. References 6: 4 Russian, 2 Western in translation.  
[237-6508]

UDC: 621.395.127:621.395.344.6

DETERMINATION OF RESTORAL TIME OF NON-BLOCKING MALFUNCTIONS IN CROSSBAR EXCHANGES

Moscow ELEKTROSVYAZ' in Russian No 3, Mar 82  
(manuscript received 9 Apr 80) pp 32-34

SINYAKOV, A. R.

[Abstract] There are three methods which can be used to determine restoral time of non-blocking malfunctions, i.e., malfunctions in which the equipment continues to establish a connection, rather than becoming blocked: expert panels, artificial malfunctions and analytical methods. Numerical estimates of the restoral time of non-blocking malfunctions in automatic crossbar exchanges obtained from experimental data can be used for engineering calculations of the performance and reliability indicators of automatic crossbar exchanges. Figures 2; references 8: 7 Russian, 1 Western.  
[237-6508]

PECULIARITIES OF NONLINEAR DYNAMICS OF SYSTEMS FOR QUASI-COHERENT  
FILTRATION OF COMPLEX SIGNALS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 7 Jul 80) pp 1672-1677

TUZOV, G. I., SPIRIN, V. V. and PRYTKOV, V. I.

[Abstract] On the basis of mathematical modeling and an analysis of the structure of two phase space equations, some results are presented of an investigation of the dynamics of systems of quasi-coherent filtrations of wide band pseudorandom signals. The following points are examined in the work: 1) Combined nonfiltration system of automatic phase control [APC] and a system of tracking after delay [TAD]; 2) Combined system of APC and TAD with low-frequency filters; and 3) Combined system of APC and TAD of the first orders. An analysis of the conditions of entry into a regime of synchronism of two-circuit systems of filtration of complex signals shows that with any values of the parameters there also exists a region of initial conditions. Beginning with this region, establishment of a regime of synchronism is impossible. The boundaries of this region determine the precision of search for a signal and the corresponding extent of time expenditure. This, as in the case of coherent systems, leads to the necessity for taking a priori data into consideration. In a quasi-coherent system, capture of a signal takes place with a larger range of changes of the input frequency than for a coherent receiver, and it is possible to accomplish search for a signal separately. In a search regime, it is possible to reduce the requirements with respect to precision considerably and thereby to reduce considerably the time of entry of the tracking system into synchronization. Figures 8; references: 5 Russian. [88-6415]

BASAL ALGORITHM OF DISCRETE SPACE-TIME PROCESSING ACCORDING TO MAXIMUM-  
LIKELIHOOD PRINCIPLE

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 11 Dec 80) pp 55-57

CHAYKOVSKIY, V. I.

[Abstract] The procedure for space-time processing of narrow-band signals according to maximum likelihood is reduced to one analogous to that for simultaneous detection and estimation of a useful signal by time processing according to maximum likelihood. The basal algorithm of this processing involves forming a hypersurface of sufficient statistics above the variation field of the vector of estimated parameters, determining the coordinates of its global maximum, and comparing this maximum with some threshold

according to a certain decision rule for hypothesis testing. A typical case is a narrow-band signal with random initial phase submerged in stationary Gaussian interference. In the processing the transform of the excitation as well as both signal and interference components of the observation are first put in the form of matrices, which are then developed into vector-columns, whereupon the vector representation is introduced. The computation volume can be reduced by taking into account the characteristic features of the space-time correlation function of a scalar isotropic noise field. It will be further reduced by absence of correlations between field receptors. References: 4 Russian.  
[203-2415]

UDC 621.396.62.019.4

#### METHODS OF FREQUENCY CONVERSION IN SUPERHETERODYNE RECEIVER

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 18 Feb 81) pp 91-93

SARAYEV, S. M.

[Abstract] Several methods of frequency conversion in a superheterodyne receiver are compared ( $\omega_i$  - intermediate frequency,  $\omega_0$  receiver tuning frequency), namely: with upper tuning of heterodyne frequency  $\omega_h$  or its  $m_0$ -th harmonic ( $\omega_i = m_0\omega_h - \omega_0$ ), with lower tuning of heterodyne frequency  $\omega_h$  or its harmonic ( $\omega_i = \omega_0 - m_0\omega_h$ ), and by adding ( $\omega_i = \omega_0 + m_0\omega_h$ ) or subtracting. Limits of the tuning band and the overlap factor are established in each case on the basis of known relations with the aid of the frequency chart. The design of a receiver requires a tradeoff between width of tuning band and frequency separability in terms of filter power. Figures 1; tables 2; references 3: 2 Russian, 1 Western.  
[203-2415]

UDC 621.396.96:621.391.26

#### DETECTION BY ADAPTIVE RANK PROCEDURE

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 30 Mar 81) pp 40-43

AKIMOV, P. S. and LYSYY, V. M.

[Abstract] The truncated sequential procedure for multichannel detection with use of rank-sum nonparametric statistics and of the Neyman-Pearson criteria for the number of observations for given correct-detection probability and false-alarm probability (the latter independent of the

interference characteristics) is modified to an adaptive one where these two characteristics are maintained through adjustment of the full number of observations  $n_0$  and the corresponding detection threshold  $C$ . The adaptation process involves estimation of two integrals of the interference distribution function with respect to the signal+interference mixture distribution function during the first  $n'$  observations, and then solving two equations for  $n_0$  and  $C$  on the basis of those estimates. An adaptive multichannel device with time resolution is shown which implements this algorithm. It includes a receiver, a nominal-signal generator, a summator, two detectors, two rank calculators, a reference-sample memory, a calculator of adaptation parameters, a read-only memory, a lower-threshold calculator and a rank storage. The detection characteristics of this device with generally nonidentical channels have been analyzed by the method of statistical simulation, assuming a Rayleigh distribution of interference and a Rice distribution of signal+interference mixture. The estimates of correct-detection probability agree closely with those for a Weibull interference envelope. Figures 5; references 8: 7 Russian, 1 Western.  
[203-2415]

UDC 621.396.674.1

#### ESTIMATING PARAMETERS OF OBJECT MOVEMENT IN INDUCTIVE COMMUNICATION SYSTEMS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 18 Jun 81) pp 3-8

IVANOV, V. S. and UL'YANITSKIY, Yu. D.

[Abstract] Inductive wireless communication inside industrial facilities is an effective means of monitoring the movement of transported objects, and is preferable to ultrashort-wave communication over relatively small floor areas (up to 20 ha). A transmitter with a loop antenna is mounted on the object. Receiver antennas are mounted under the roof above the control equipment. From a general expression for the signal induced in the receiver by the transmitter, dependent on the transmitter parameters and the carrier frequency as well as on the receiver geometry, relations are derived for estimating the instantaneous location and velocity of the object. The attainable accuracy of these estimates, determined on the basis of statistical analysis of uncorrelated time and velocity measurements according to the maximum-likelihood principle, indicates what the design parameters of the optimum receiver should be. Changes in the location of the transmitter do not affect the accuracy of measurements. Figures 2; references: 4 Russian.  
[203-2415]

## CRITICALITY OF SYNTHESIZED RECEIVERS OF INTERFERING RADIO PULSE SIGNALS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 26 Jan 81) pp 52-55

RYABTSOV, A. L.

[Abstract] Optimum receivers synthesized according to the theory of conditional Markov processes for nonlinear filtration are critical with respect to changes in parameters and characteristics of incoming useful and interference signals. Here algorithms of determining the criticality of such receivers are outlined for the case of interfering radio pulses at the input, specifically an additive mixture of useful and interference signals. The interference signal is assumed to be a stationary normal white noise with known statistical characteristics. The useful signal is the sum of two sequences of video pulses of unit amplitude. The parameters to be estimated are the delay time of such signals relative to reference pulses and the lag time from direct signal to reflected signal arriving at the input, both parameters assumed to be exponentially correlated stationary Gaussian processes. Equations for the cumulants of these parameters, after averaging over a period of the reference signal, are put in generalized form and from their solution are obtained the respective criticality parameters. Results of computer simulation of such a receiver reveal how the loss of accuracy increases with increasing deviation of the input signal-to-noise ratio from its nominal value. Figures 1; references: 4 Russian.  
[203-2415]

## UTILIZATION OF HYSTERESIS IN THRESHOLD RECEIVERS FOR TELEMETRY

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 30 May 80) pp 63-66

SHAKHMARDANOV, Sh. M., IOANESYAN, V. R. and MASLENNIKOV, V. K.,  
Azerbaijan Institute of Petroleum and Chemistry imeni M. Azizbekov

[Abstract] Hysteresis in the threshold device with a low-pass filter in a telemetry receiver provides interference and false-alarm immunity. This is demonstrated in the case of an input signal consisting of a constant-current pulse and fluctuation noise with zero mean. A relation is established between the necessary hysteresis voltage and input signal parameters: residual interference level and product of ratio of filter passband to interference frequency by ratio of signal amplitude to interference amplitude. Residual interference is assumed to be a narrow-band random process with both amplitude and phase slow functions of time. The leading edge of the signal is assumed to be a ramp. A threshold receiver is designed on this

basis which consists of a comparator built with a series K140UD7 integrated analog microcircuit and a generator of threshold bias voltage. The output of the microcircuit is connected to its noninverting input through a resistive voltage divider forming the hysteresis voltage. The necessary hysteresis voltage can be found from design curves for given performance requirements such as the signal-to-noise ratio at the filter output. The paper was recommended by the Department of Information-Measurement and Computing Techniques. Figures 2; references: 3 Russian. [202-2415]

UDC 636.391

#### EFFICIENCY OF RANDOM PULSE SIGNAL RECEPTION ON BACKGROUND OF WHITE NOISE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 29 Oct 79) pp 1622-1630

TRIFONOV, A. P. and GALUN, S. A.

[Abstract] The asymptotic points (with an increase of the duration of the signal  $\gamma$  and the a priori interval  $T_0$ ) are found of an expression for the characteristics of detection of a random signal and an evaluation of its time-dependent state in a receiver of maximum probability. The following items are considered in the work: 1) Output signal of receiver of maximum probability; 2) Detection of random pulse signal; and 3) Evaluation of time-dependent state of random pulse signal. References 12: 11 Russian, 1 Western. [88-6415]

UDC 772.99:77.02.8

#### OPTICAL METHODS OF SIGNAL SEPARATION FROM PERIODIC BACKGROUND NOISE

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 25, No 2, Feb 82 (manuscript received 8 Jan 81) pp 199-203

ZVEREV, V. A., KOSOBURD, T. P. and MARKUS, F. A., Gor'kiy State University

[Abstract] An optical method not requiring special filters is considered for separation of signals from multiplicative periodic background noise. The equipment consists of a source of coherent light at a given wavelength in free space, an expander forming a parallel light beam, a diaphragm, and a transparency carrying signal  $s(x)$  and noise  $n(x)$  with a field  $E(x,0) = s(x)n(x)$  behind. It is demonstrated by an analysis of diffraction patterns within constraints of geometric optics that a certain distance behind the transparency, preferably within the near zone, the free space acts as a filter transforming the field so as to attenuate or even eliminate

the noise when the period of the latter does not exceed a limit determined by the system parameters. Figures 4; references: 7 Russian.  
[201-2415]

#### SMALL COMPUTER AT CENTER OF TECHNICAL OPERATION OF TELEPHONE JUNCTION

Moscow VESTNIK SVYAZI in Russian No 2, Feb 82 pp 27-29

ZELICHENOK, M. I., senior engineer, Petrograd Telephone Junction of Leningrad Urban Telephone Network, KOPYTIN, V. V., deputy chief, Leningrad Urban Telephone Network, and NESTERENKO, V. D., chief, Central Technical Operations of Vyborg Telephone Junction

[Abstract] A problem-oriented complex with an ISKRA-1256 small computer at the base has been installed in the Leningrad urban telephone network for centralized acquisition and processing of data from 15 inspection objects. Data are transmitted by the standard No. 5 international telegraph code, for which 126 binary signals and 126 inputs are available. The interrogation time is 16-90 s per object, depending on the number of emergency signals received, and the response is transmitted in 19 byte packets. The control line is supplied with  $\pm 60$  V, draws at least 25 microampere, and has a range of 12 km along TPP-0.5 cables or 25 km along TPP-0.7 cables. The computer complex includes, in addition to the ISKRA-1256 processor-interpreter, 10 auxiliary devices: keyboard, analog-to-digital converter-printer, 6 interface modules (printout, 4-kbyte memory expander, timer, two teletypes, commutator), audio-visual signalling module, data collection and transmission module. The complex operates according to a program, with two buffer zones in the computer memory for sequential interrogation of an object. A difference between consecutive data input cycles is displayed on the dispatcher's screen and recorded on magnetic tape for subsequent statistical evaluation. Output data are displayed on two formats, the first one indicating the state of all objects and the second one decoding the state of each object individually. The complex is located at the Technical Operations Center of the Petrograd telephone junction. Since its installation it has reduced the network operating costs by 52,400 rubles annually. Figures 3.  
[198-2415]

## COMPONENTS, HYBRIDS & MANUFACTURING TECHNOLOGY

### DEVICE FOR CALCULATING WALSH FUNCTION SPECTRUM

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 27, Jul 81 pp 197-198

[Translation of Patent number 849224]

[Text] A device for computing the spectrum of Walsh functions is disclosed which contains a counter, address unit, constant assignment unit, multiplication unit, summator, switch, comparison unit, flip-flop, cycle-number former, AND element and control unit with first output connected to the first input of the flip-flop the first output of which is connected to the first input of the AND element, the output of which is connected to the first input of the control unit; the second input of the AND element is connected to the first output of the cycle-number former, the input of which is connected to the output of the summator; the second output of the cycle-number former is the first output of the device and is connected to the first inputs of the switch and comparison unit, the output of which is connected to the second input of the flip-flop, the second output of which is connected to the second input of the switch, the output of which is connected to the first input of the address unit, the output of which is connected to the input of the constant-assignment unit, the output of which is connected to the first input of the multiplication unit, the output of which is the second output of the device; the input of the counter is the first input of the device, the input of the register is the second input of the device, and the output of the register is connected to the second input of the comparison unit. This device is distinguished by the fact that in order to increase speed and expand functional capabilities by determining the spectrum of Walsh and Rademacher functions using their numbers alone without generating the functions in time, the device uses a group of AND elements, Gray code generator, shift register, cyclic shift register and sign formation unit, the output of which is connected to the second input of the multiplication unit; the input of the signal formation unit is connected to the first input of the shift register and the first output of the Gray code generator, the second and third outputs of which are connected respectively to the first and second inputs of the summator; the input of the Gray code generator is connected to the output of the counter; the second input of the address unit is combined with the second input of the control unit and connected to the outputs of the AND elements in the group, the inputs of which are connected to the first output of the shift register, the second output of which is connected to the third input of the address unit, the fourth input of which is connected to the output of the cyclic shift



register, the first input of which is connected to the second input of the shift register and to the second output of the control unit; the second input of the cyclic shift register is connected to the third output of the control unit.

2. A device is disclosed, as described above, which is distinguished by the fact that the control unit contains four AND elements, a frequency divider, pulse generator, shift register and univibrator, the output of which is connected to the input of the pulse generator, the outputs of which are connected to the first inputs of three AND elements and the timing input of the shift register, the first and second outputs of which are connected to the second inputs, respectively, of the first and second AND elements, the outputs of which are, respectively, the first and third outputs of the control unit; the first and second inputs of the fourth AND elements are, respectively, the first and second inputs of the control unit, and the output of the fourth AND element is connected to the second input of the third AND element, the output of which is connected to the input of the frequency divider, the output of which is the second output of the control unit; the inputs of the shift register and univibrator are combined and serve as the control input of the device.

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## VECTOR PROCESSOR

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 27, Jul 81 p 199

[Translation of Patent number 849228]

[Text] A vector processor is disclosed which contains a read-only memory, synchronization unit, iteration counter, dual iteration flip-flop, shift signal shaper, address formation unit, operation sign formation unit, two linear coordinate processing units, and an angular coordinate processing unit: each linear coordinate processing unit contains a receive register, output register, bumper register, adder-subtractor and shift switch; the angular coordinate processing unit contains a receive register, output register, buffer register, and adder-subtractor. The first output of the synchronization unit is connected to the first input of the iteration counter and the input of the dual iteration flip-flop; the second output of the synchronization unit is connected to the first input of the operation sign formation unit; the first inputs of the receive registers and buffer registers and the third output of the synchronization unit are connected to the second input of the operation sign formation unit and to the first inputs of the output registers; the fourth output of the synchronization unit is connected to the first inputs of the shift signal formation unit and address formation unit; the fifth output of the synchronization unit is connected to the third input of the operation sign formation unit, the fourth, fifth, sixth and seventh inputs of which are connected respectively to the output of the receive register of the angular coordinate processing unit, to the first outputs of the output register, the angular coordinate processing unit, and the first and second linear coordinate processing units; the first output of the dual iteration flip-flop is connected to the second inputs of the iteration counter and the address formation unit, the output of which is connected to the input of the read-only memory; the second output of the dual iteration flip-flop is connected to the eighth input of the operation sign formation unit and to the second input of the shift signal formation unit; the output of the iteration counter is connected to the third inputs of the address formation and of the shift signal formation unit, the output of which is connected to the first inputs of the shift switches of the first and second linear coordinate processing units; the output of the operational sign formation unit is connected to the first inputs of the adder-subtractors; in each of the linear coordinate processing sections the output of the shift switch is connected to the second input of the adder-subtractor, the third input of which is connected

to the output of the buffer register; the output of the adder-subtractor is connected to the second input of the output register; the second input of the shift switch is connected to the output of the receive register; the second output of the output register of each linear coordinate processing unit is connected to the second inputs of the buffer register of its own and of the receive register of the other linear coordinate processing section; in the angular coordinate processing section the output of the adder-subtractor is connected to the second input of the output register, the second output of which is connected to the second input of the buffer register, the output of which is connected to the third input of the adder-subtractor. This processor is distinguished by the fact that in order to increase output and expand the class of solvable problems, the angular coordinate processing section uses a shift switch with its output connected to the input of the adder-subtractor of the unit; the first and second inputs of the shift switch are connected respectively to the outputs of the shift signal formation section and read-only memory; the third inputs of the shift switches of the linear coordinate processing units and angular coordinate processing unit are connected respectively to the output of the buffer registers of these units, while the output of the receive register of the angular coordinate processing unit is connected to the fourth input of the shift switch and the third input of the buffer register serving that unit.

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## RANDOM PULSE SEQUENCE GENERATOR

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 26, Jul 81 p 26

[Translation of Patent number 847498]

[Text] A random pulse sequence generator is disclosed which contains a code sequence generator, decoder and switching section. This generator is distinguished by the fact that in order to expand functional capabilities by regulating the principle by which the time interval between pulses is varied it uses a delay unit and, in series, a pulse shaper, interrupt unit and time interval formation unit, the output of which is connected to the first input of the switching unit, the second input of which is connected through the delay unit to the output of the pulse shaper, the input of which is connected to the output of the switching unit; the third input of the switching unit is connected through the decoder to the output of the pulsed sequence generator.

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## RANDOM NUMBER GENERATOR

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 45, Dec 81 pp 231-232

[Translation of Patent number 888117]

[Text] A random number generator is disclosed which contains a primary random signal source with output connected to the first input of a first AND element and to the first input of a comparison section, the second input of which is connected to the output of a memory section and the output of the comparison section connected to the second input of the first AND element and to the inverse input of the second AND element, and a dynamic memory section. This generator is distinguished by the fact that for simplification it contains an OR element with output serving as the output of the generator and being connected to the input of the dynamic memory section, the output of which is connected to the direct input of the second AND element, the output of which is connected to the first input of the OR element, the second input of which is connected to the output of the first AND element.

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## DEVICE FOR DETECTING MOMENT AT WHICH PROPERTIES OF RANDOM PROCESS CHANGE

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 45, Dec 81 p 237

[Translation of Patent number 888133]

[Text] 1. A device is disclosed for detecting the moment at which the properties of a random process change which consists of a control unit, the first output of which is connected to the first input of an analog-digital converter, the second input of which is the input of the device, a multiplication section, summator and two shift registers. This device is distinguished by the fact that in order to expand its functional capabilities by determining the moment at which the mathematical expectancy and correlation function change, it uses five registers, three shift registers, three OR elements, two AND elements, a delay element and start button. The first input of the first register is combined with the first input of the second register and connected to the first input of the control unit; the output of the first shift register is connected to the first input of the first shift register and to the first input of the first OR element, the second output of which is combined with the first inputs of the second shift register and connected to the output of the second shift register; the first input and output of the third shift register are combined and connected to the first input of the second OR element, the output of which is connected to the input of the summator, whose first input is connected to the first input of the fourth shift register, the fourth output of which is connected to the first input of the third OR element, the second of which is combined with the second input of the first OR element and connected to the second output of the fourth shift register; the output of the second register is connected to the third input of the third OR element, the output of which is connected to the first input of the multiplication section, the second of which is connected to the output of the first OR element; the first output of the multiplication section is connected to the second input of the second OR element, the third element of which is connected to the output of the fifth shift register, the first input of which is connected to the second output of the summator, the third output of which is connected to the first inputs of the first and second AND elements, the output of which is connected to the first input of the control section; the outputs of the third, fourth and fifth registers are connected respectively to the fourth, fifth and sixth inputs of the second OR element, the seventh input of which is connected to the output of the first register; the second input is combined with the second inputs of

the fourth and fifth shift registers and connected to the second output of the control unit; the third input of the first register, fourth and fifth shift registers are combined and connected to the third output of the control unit, the fourth output of which is connected to the second inputs of the second register and first shift register, the fourth input of the fifth register and the second input of the third shift register, the third input of which is combined with the third inputs of the second register and first shift register and with the fifth input of the fifth shift register and connected to the fifth output of the control unit, the sixth output of which is connected to the fourth input of the fourth shift register; the seventh output of the control unit is connected to the fifth input of the fourth shift register, the sixth input of which is combined with the third input of the third shift register and connected to the eighth output of the control unit, the ninth output of which is connected to the third input of the second shift register and the seventh input of the fourth shift register, the eighth input of which is connected to the second output of the multiplication section; the input of the third register is connected to the tenth output of the control unit, the eleventh output of which is connected to the first input of the fifth register, the second input of which is connected to the output of the first AND element, the second input of which is connected to the twelfth output of the control unit; the thirteenth output of the control unit is connected to the second input of the second AND element, to the third input of the fifth register and to the input of the fourth register; the fourth inputs of the first and second register are combined and connected to the output of the analog-digital converter; the output of the start button is connected to the second input of the control unit and through a delay element to the fifth input of the first register.

2. A device is disclosed as described above which is distinguished by the fact that the control unit contains a pulse generator, AND element, flip-flop and twelve delay elements in series; the output of the pulse generator is connected to the first input of the AND element, the second input of which is connected to the output of the flip-flop, the ones input of which is the second input of the unit; the zero input of the flip-flop is the first input of the unit; the output of the AND element is the first output of the control unit, and the outputs of the delay elements are connected respectively to the outputs of the second through the thirteenth control units.

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## RANDOM PROCESS GENERATOR

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 27, Jul 81, p 243

[Translation of Patent number 849464]

[Text] A random process generator is disclosed, as described in Patent number 439064, which is distinguished by the fact that in order to expand functional capabilities by automating the regulation of the statistical characteristics of the process being monitored it uses additionally, in series, a sync pulse generator, synchronizer, control pulse generator, pulse shaper, memory, register and decoder; the output of the control pulse generator is connected to the control input of the memory and to the input in the zero state of the register; the second output of the synchronizer is connected to the input of the master pulse generator, while the outputs of the additional decoder are connected to the corresponding inputs of the switch.

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## PSEUDORANDOM NUMBER GENERATOR

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 46, Dec 81 p 258

[Translation of Patent number 890391]

[Text] A pseudorandom number generator is disclosed which contains an  $m$ -bit shift register, first OR element with inverse output of  $m$ th shift register bit connected to its first input, a second AND element with direct output of  $m$ th bit of shift register connected to its first input, and an OR element with its output connected to the input of the first bit of the shift register. This generator is distinguished by the fact that in order to increase accuracy it contains a third AND element, fourth AND element and an NOR element. The inverse and direct outputs of the  $j$ th bit of the shift register are connected respectively to the second inputs of the first and second AND elements; the outputs of the first and second AND elements are connected to the first and second inputs of the NOR element; the inverse outputs of the  $m - 1$  first bits of the shift register are connected to the inputs of the fourth AND element; the output of the fourth AND element is connected to the third input of the NOR element and the first input of the third AND element, to the second input of which is connected the inverse input of the  $m$ th bit of the shift register; the output of the NOR element is connected to the first input of the OR element, to the second input of which is connected the output of the third AND element.

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UDC 621.372.853.2

FERRITE VALVE-FLANGE FOR 4-MM WAVE BAND

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 4 Dec 80) pp 80-82

BOCHKAREV, A. I. and KURUSHIN, Ye. P.

[Abstract] The feasibility of producing valves for the 4-mm wave band analogous to those for the 7-8 mm wave band within the  $l\omega^p = \text{const}$  constraint ( $l$ - length,  $\omega$ - radian frequency,  $p$ - small number) has been established on the basis of numerical simulation of an H-plane two-dimensional valve-flange model. The electrodynamic characteristics of such a device using commercial ferrite materials were calculated, specifically forward and backward power losses and reflection coefficient at valve input over the 64-70 GHz frequency range for coupling  $3.6 \times 1.8 \text{ mm}^2$  waveguides. The results reveal the dependence of these characteristics on the position of the ferrite-dielectric resonator inside the coupler. These results serve as basis of experimental development of such valves. Figures 3; references: 9 Russian.  
[203-2415]

# RATIONAL DESIGN OF ELECTRODES IN SYMMETRIC STRIPLINES FOR FORMATION OF HEAVY NANOSECOND PULSES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian  
No 2, Feb 82 (manuscript received 26 Mar 81) pp 17-22

NOVGORODTSEV, A. B., candidate of technical sciences, docent, Order of Lenin Polytechnic Institute imeni M. I. Kalinin, Leningrad, and  
FAKHTIYEV, A. R., candidate of technical sciences, Institute of Aviation imeni S. Ordzhonikidze, Ufa

[Abstract] Stripline storage devices, or coaxial lines, are used with generators of heavy nanosecond pulses for controlling the power and the duration of these pulses. Their performance depends largely on limitation of the maximum electric field intensity at the edges of the electrodes, which usually have rounded corners. Here a procedure for designing the center electrode in a symmetric stripline is shown which will ensure a uniform maximum electric field intensity along a rounded corner. Calculations are made by the method of conformal mapping, with the center electrode of finite width assumed to be under a voltage and the outer two electrodes at zero (ground) potential assumed to be infinitely wide. Relations are established between the pertinent relative dimensions of the center electrode, the spacing of the electrodes on the stripline, and the ratio of electric field intensity at the corner to voltage gradient across the stripline. These relations are presented graphically in the form of curves, for design calculations. Figures 3; references 3: 2 Russian, 1 Western.  
[242-2415]

# ANALYSIS OF NOISE PARAMETERS AND DESIGN OF LOW-NOISE WIDEBAND AMPLIFIERS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received 6 Jul 81) pp 24-25

IGNATOV, B. N., KONDRATENKO, S. V. and KOROLEV, V. A.

[Abstract] The feasibility of numerically tabulating not only the signal characteristics but also the noise characteristics of transistors, on the basis of the equivalent circuit diagram, is established for the typical case of a bipolar device. Such tables are useful for computer-aided design of low-noise wideband amplifiers. Figures 4; tables 1; references 4: 2 Russian, 2 Western.  
[203-2415]

## ANALYSIS AND CALCULATION OF FREQUENCY INSTABILITY IN CONTROLLED QUARTZ OSCILLATOR

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 22 Jun 81) pp 85-88

MASLOV, V. A.

[Abstract] Frequency instability in a controlled quartz oscillator is analyzed for the case of an input reactance of the generator circuit much lower than the reactances in the frequency control circuit. Calculations yield the same instability coefficient regardless of the branch of the tank circuit into which the active device has been inserted. The relation between frequency and control voltage depends intricately on the frequency deviation range and can become unstable, at different rates, because of instability of various circuit components. The stability of this relation can be improved by design. A family of curves is available as convenient aid for calculations. Figures 2; references 8: 5 Russian, 3 Western.  
[203-2415]

## TUNED AMPLIFIERS USING MOS POWER TRANSISTORS AND THEIR DESIGN WITH AID OF DIGITAL COMPUTER

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 18 May 81) pp 83-85

D'YAKONOV, V. P. and SEMENOVA, O. V.

[Abstract] A procedure for designing tuned amplifiers with MOS power transistors (KP901 and KP904 for frequencies up to 100 MHz with power rating up to 10 and 50 W, respective, KP907 with power rating up to 12 W at 0.5 GHz and up to 6 W at 1 GHz) is outlined, including the use of schematic and equivalent circuit diagrams and linear-exponential approximation of the current-voltage output characteristic. The complete system of nonlinear differential equations of state for the output stage is solved by the implicit Euler method on a digital computer, which also calculates transient and steady-state performance characteristics. Typical parameters, curves and oscillograms for a class B amplifier are shown. Figures 4; references: 5 Russian.  
[203-2415]

UDC 681.327.001

## INFLUENCE OF DESIGN FACTORS ON WRITE CURRENTS IN PROM'S WITH FUSIBLE LINKS

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 11 Feb 81) pp 20-24

CHISTYAKOV, Yu. D., MIKADZE, V. V. and MOSHKIN, V. I., Institute of  
Electronic Engineering, Moscow

[Abstract] An analysis is made of the influence of design factors on write currents in PROM's (programmable read-only memories) which are programmed by breaking fusible links, and are heated by electric current and volatilized. High write current densities on the order of  $2.5 \cdot 10^7$  A/cm<sup>2</sup> are required for breaking fusible links in presentday PROM integrated circuits, and this makes a further increase in level of integration to greater than 64 to 128 K bits on a chip practically impossible, because of the increased probability of failure with a reduction in size of circuit elements. The only viable alternative is to reduce write currents by the control of design factors. Reducing the dimensions of fusible links too drastically reduces the reliability of the PROM, on account of electromigration, in particular. The value of the critical write current and time required for reaching the critical temperature for fusing or softening the link's material are determined by solving an equation describing the heat balance in a model of a PROM element. The critical write current density required for breaking a link is determined from the condition for reaching the critical temperature. It is demonstrated that the required write current density,  $j_0$ , can be reduced by making fusible links out of materials with low values of parameter  $(T_{kr} - T_0)/\rho$ , where  $T_{kr}$  is the critical temperature mentioned above and  $T_0$  is the initial temperature and  $\rho$  is the resistivity. In order to reduce the critical current,  $I_{kr}$ , it is feasible to reduce the width of a link. Two methods of lowering  $T_{kr} - T_0$  are investigated: uniform heating of the PROM chip, and achieving a local increase in the temperature of the fusible link to be broken on account of an external source, e.g., a laser beam, or a source built into the structure of the PROM. It is possible to use heat released in active or passive elements of the PROM to achieve a local increase in  $T_{kr}$  without increasing the current through it. The heat released in the write mode in decoupling diodes can be used in PROM's based on diode arrays. The fusible link is then positioned near the heat release zone.

Decoupling diodes are back-biased since lower current is thereby required for heating their p-n junctions than with forward biasing. By placing fusible links above the heat releasing elements of the PROM it is possible to lower write currents by more than an order of magnitude, or 10- to 50-fold, and to create the conditions required for increasing the level of integration. Figures 3; references 8: 6 Russian, 2 Western (1 in translation).  
[210-8831]

UDC 621.373.826:772.99

# SYNTHESIS OF AMPLITUDINAL SPACE-FREQUENCY FILTERS FOR COHERENT OPTICAL PROCESSOR

Leningrad IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 20 Jul 80) pp 30-34

OCHIN, Ye. F., Leningrad Institute of Precision Mechanics and Optics

[Abstract] Two pairs of non-negative amplitudinal space-frequency filters are synthesized by application of optical holography, one for a differentiating filter

$\frac{\partial}{\partial x} \alpha(x,y)$  with transfer function  $H(\xi, \eta) = c\xi$  ( $c = 2\pi/\lambda f$ ,  $\lambda$ - wave-

length of light,  $f$ - focal length of lens) and one for a differentiating filter

$\frac{\partial}{\partial x \partial y} \alpha(x,y)$  with transfer function  $H(\xi, \eta) = c\xi$  ( $c \rightarrow -4\pi^2/\lambda f$ ). More

universal methods, for filters with arbitrary transfer functions, are those of digital holography such as binary coding with phase modulation at only two levels 0 and 1. A comparative analysis of width coding, height coding and width-height coding in a typical 6x6 Loman cell for accuracy indicates that the error is, respectively, 12.5, 4.2 and 3.15%, the error of optimal coding being 2.1%. The technology of filter synthesis by digital holography involves first magnification of a synthesized hologram taken from the computer and then photographic reduction of the hologram, the latter process introducing uncontrollable errors. At least one method of synthesis is already available, based on electron-beam lithography, which does not require reduction. The paper was recommended by the Department (Kafedra) of Computing Techniques. Figures 5; references 4: 1 Russian, 3 Western.  
[202-2415]

## CONTRAST DISSIPATIVE STRUCTURES AND DOMAIN WALLS IN ACTIVE DIFFUSION MEDIUM

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 26 Jan 81) pp 25-29

BALKAREY, Yu. I., YEVTIKHOV, M. G. and YELINSON, M. I., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] Three-dimensional stratification originates under certain conditions in active kinetic systems of the diffusion type and in strongly non-equilibrium systems this type of stratification has been called a three-dimensional dissipative structure. Dissipative structures can be used to create active memory systems which not only record but also partly process three-dimensional information, such as isolation of the outlines and corners and the regeneration of certain lost elements of a picture. Three-dimensional dissipative structures are divided into quasi-harmonic and contrast. Previous studies by the authors (1979, 1980) were devoted to discussion of the processes of the formation in time of various periodic and non-periodic unidimensional and two-dimensional contrast structures, by means of a numerical experiment, on the basis of a specific mathematical model of an active medium with diffusion. The discussion was limited to cases when a three-dimensional homogeneous system, i.e., a point model, had self-oscillating or potentially self-oscillating properties, corresponding to the delay mode, when the system, after the final impulse, issues a drive pulse and returns to the original state. In the present paper a system is discussed in which the point model has trigger properties. The medium is described by two equations which under certain conditions provide a qualitative description of the Belousov-Zhabotinskiy chemical "autowave" medium. The model used is typical of the class of active diffusion systems but is expanded and some parameters are changed to produce the trigger mode. In the trigger mode the structures are in the form of wide domains bounded by narrow domain walls separating stable stationary states. The formation of domain walls and the transformation of a stationary structure into a set of moving domain walls when the system is switched from the delay to the trigger mode are discussed. An illustration is given of the process of the formation of a domain wall from a stepped initial perturbation. An illustration is given of the transformation of a stationary system of narrow and wide strata formed in the delay mode after switching to the trigger mode. Narrow strata slowly broaden on account of movement of the walls and walls disappear when they meet one another and boundaries. In the trigger mode, as distinct from the delay mode, a three-dimensionally inhomogeneous perturbation applied to the medium does not change its form up to the conversion of boundaries into domain walls if the velocity of the walls is low, or the region of the initial perturbation expands on account of movement of the walls. Boundaries which are fuzzy at the starting moment are converted into walls and become sharp. It is therefore possible to use the medium in this mode as a memory which, with a slow rate of movement of the domain walls, preserves the form of the initial perturbation, just correcting its boundaries. The trigger mode discussed adds to the possibilities of using an "autowave" medium as an active memory. Figures 6; references 13: 11 Russian, 2 Western.  
[210-8831]

# QUANTITATIVE CHARACTERISTICS OF IMPROVING RELIABILITY OF SEMICONDUCTOR MEMORIES BY ERROR DETECTION AND CORRECTION

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 23 Mar 81) pp 109-112

BORISOV, V. S.

[Abstract] The reliability of large-capacity semiconductor memories built on the basis of large-scale integration is now more widely improved by structural-circuitual engineering methods using error detection and correction algorithms with the necessary degree of hardware redundancy. As a quantitative criterion of reliability improvement can serve an indicator of longer mean time between failures. The probability of an error occurring twice in the storage device is expressed through the probability of an error occurring once in the nonredundant version of this device, the ratio of both probabilities becoming the reliability improvement factor. Here analytical expressions are derived for both probabilities and the reliability improvement factor is calculated for a typical LSI memory with linear code modules and error correction. The results reveal that the reliability improvement factor decreases with increasing word length, with longer operating time, and with an increasing failure rate. The design of error detection and correction systems for memories depends on the scale of integration, among others, busbar-processor and processor-memory interfaces of the coupling kind being appropriate in large-scale integration. Figures 2; references 11: 10 Russian, 1 Western.  
[250-2415]

# CHARACTERISTICS OF ELECTRICALLY REPROGRAMMABLE MOS COMPONENTS IN MEMORY WITH FLOATING ELECTRODES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 2 Dec 80) pp 152-157

BELYAYEV, S. N., KOLYASNIKOV, V. A., RAKITIN, V. V., STARIKOVA, T. I., TISHIN, Yu. I. and ENKOVICH, V. A.

[Abstract] Structures Si-SiO<sub>2</sub>-Si(polycrystalline)-SiO<sub>2</sub>-metal, where polycrystalline silicon serves as floating electrode, are used in electrically reprogrammable read-only memories. This is feasible because of the higher electrical conductivity of SiO<sub>2</sub> thermally grown on polycrystalline silicon and the possibility of varying the charge on the floating electrode upon application of a voltage pulse to metal electrode. Here are examined the polarization characteristics of such structures, the current-voltage characteristic of SiO<sub>2</sub> on polycrystalline silicon, and degradation as a result



of switching. The theoretical analysis is based on the Fauler-Nordheim relation describing the electron tunneling mechanism in the recording mode and on the Schottky relation describing the mechanism of electron emission through a barrier lowered by an external field in the charge storage mode. The theoretical results agree qualitatively with experimental data obtained with a polycrystalline silicon layer doped with phosphorus to concentration  $n \geq 10^{19} \text{ cm}^{-3}$ , on a p-Si substrate and under an aluminum upper electrode. Figures 6; references 5: 2 Russian, 3 Western. [250-2415]

UDC 681.3

#### ANALYSIS OF DYNAMIC PROPERTIES OF TIME-PULSE QUADRATIC DEMODULATORS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 24, No 11, Nov 81 (manuscript received 28 Nov 80) pp 63-67

GERASIMOV, I. V. and KOSTICHEV, S. V., Leningrad Electrical Engineering Institute imeni V. I. Ul'yanov (Lenin)

[Abstract] The paper discusses a method for obtaining one of the mathematical models of time-pulse quadratic demodulators, taking into account the special features of devices with neutralization of width-modulated pulse sequences. A functional diagram of the quadratic demodulator is presented. It is necessary to consider the demodulator as an open pulse system representing an electrical network with periodic commutation parameters. The paper was recommended by the Department (Kafedra) of Computing Techniques. Figures 2; references: 6 Russian. [151-6415]

UDC 621.396.662

PHASE-TRACKING AUTOMATIC FREQUENCY CONTROL SYSTEMS WITH COMPLEX FILTERS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 13 Apr 81) pp 34-37

SAFONOV, V. M.

[Abstract] A phase-tracking automatic frequency control system with a sawtooth characteristic of the phase detector, corresponding to a third-order nonlinear differential equation, is analyzed in the region of the space of equation parameters where the relative frequency deviation at the boundary of the locking band equals the relative frequency deviation on the separatrix loop. Three filters are considered: a 0/2 filter, a pair of identical proportionally integrating 1/1 filters in series, and a rejection filter. Calculations confirm the possibility of two collocations at the right-hand boundary of the separatrix plane, reveal the noise bands in each case, and yield the transmission coefficient at the frequency of external harmonic phase oscillations. The results indicate that, for equal locking bands, the noise band is wider but the filtration of external harmonic phase oscillations is better with a two-section than with a one-section 1/1 filter. Figures 1; tables 1; references: 7 Russian.  
[203-2415]

## ELECTRICAL INSULATION

UDC 537:216;311.1

### INTERCALATION COMPOUNDS OF SEMICONDUCTORS AND DIELECTRICS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 3 Jul 81) pp 90-98

KOSHKIN, V. M., All-Union Scientific-Research Institute of Monocrystals,  
Khar'kov

[Abstract] A brief survey is presented of investigation on intercalated dielectrics and semiconductors, an analysis is conducted of those common regularities of intercalated phenomena which appear to be the most important in an application of nonmetallic matrices, and finally an attempt is made to designate certain most interesting aspects of a study of intercalated dielectrics and semiconductors. The following items are considered: 1) Interaction of "Host-Guest" in intercalated crystals; 2) Interaction of "Molecule-Guest", crystal structure and stoichiometry of intercalation compounds; and 3) Some problems of physics and electronics of intercalated semiconductors. Figures 2; references 36: 23 Russian, 13 Western.  
[177-6415]

UDC 541.15

### ELEMENTARY PROCESSES OF CHARGE CARRIER FORMATION IN ORGANIC DIELECTRICS WITH RADIATION EFFECT

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 3 Jul 81) pp 31-39

YAKOVLEV, B. S., Institute of Chemical Physics, USSR Academy of Sciences

[Abstract] This paper is part of the material of the 11th All-Union Coordination Conference On Organic Semiconductors. A survey is presented of investigations made of charge carrier formation processes in organic insulators such as liquid and solid saturated hydrocarbons. The following

items are considered: 1) Two stages of formation of charge carriers; 2) Separation and initial recombinations of electron-ion pairs; 3) Thermalization and drift mobility of electrons; 4) Thermalization and drift mobility of electrons in liquid hydrocarbons; and 5) Generation of charge carriers stimulated by photo-excitation of electron-ion pairs. It is shown that various experimental data confirm the concept of formation of thermalized electron pairs by the action of ionizing radiation on organic insulators as an intermediate stage of charge carrier generation. In a description of the processes following after this stage, a satisfactory quantitative agreement with experiment for nonpolar amorphous insulators provides a diffusion (Onsager) model. The least investigated are the processes preceding the formation of thermalized pairs of charged particles--decay of autoionized states and thermalization of charge particles in the Coulomb fields of one another. In the creation of the experimental basis for the development of the theory for these processes, significant direct experimental measurements started recently of the lengths of thermalization and localization of low-energy electrons and their dependence in molecular condense media are presented. Figures 4; tables 1; references 23: 10 Russian, 13 Western.

[177-6415]

UDC 551.467:629.78

#### EFFECTIVE DIELECTRIC PARAMETERS OF SNOW CAP BASED ON RADIOMETRIC MEASUREMENTS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 17 Nov 80) pp 144-147

GERSHENZON, V. Ye., KHAPIN, Yu. B. and ETKIN, V. S., Institute of Space Research, USSR Academy of Sciences

[Abstract] A model experiment was performed for the purpose of determining the effective dielectric parameters, namely permittivity and loss tangent, of a snow cap. The brightness temperature at three radio frequencies (20, 37, 89 GHz) was measured, assuming a uniform thermodynamic temperature throughout the cap, first with a specimen of a natural triple-layer soil-snow-air structure on an almost ideally black etalon and then with a specimen of snow crust alone on an almost ideally reflecting aluminum sheet. The results of measurements reveal strong scattering of millimeter waves by snow and ice crystals. The intensity of scattering decreases as the snow cap melts and its thickness thus decreases. As the wavelength is increased, the scattering action of snow becomes weaker and the action of the ground surface becomes stronger. On the basis of established relations for the cap thickness and the emissivity of snow, in terms of the loss tangent and the real part of complex dielectric permittivity, it is thus possible to detect and explore snow caps by the radiometric method. The authors thank V. V. Meriakri for discussing some of the results. Figures 2; tables 2; references 5: 3 Russian, 2 Western.

[201-2415]

## ELECTRON DEVICES

### OPTICAL RANDOM-SIGNAL SPECTRUM ANALYZER

Moscow OTKRYTIYA, IZOBRETENIYA, PROMYSHLENNYYE OBRAZTSY, TOVARNYYE ZNAKI in Russian  
No 46, Dec 81 p 234

[Translation of Patent number 890262]

[Text] An optical spectrum analyzer for random signals is disclosed which contains optically coupled and sequentially arranged coherent light source, collimator, space-time modulator, first integrating lens and opaque screen, arranged in one of two spatial frequency planes, and optically connected transparency, second integrating lens and first photoreceptor located in the other spatial frequency plane, and optically coupled third integrating lens and second photoreceptor, plus a division section, square-root extraction section and multiplication section. This analyzer is distinguished by the fact that in order to improve the statistical properties of the average value obtained for the fluctuations of the average frequency of the spectrum of the signal being investigated it uses an averaging section; the outputs of the first and second photoreceptors are connected respectively to the first and second inputs of the division section, the output of which is connected through series-connected square-root extraction section and multiplication section to the input of the averaging section.

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ORGANIC SEMICONDUCTORS AS MODEL SYSTEMS FOR PRIMARY PHOTOPROCESSES IN  
PHOTOBIOLOGY

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR; SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 3 Jul 81) pp 40-54

FRANKEVICH, Ye. L. and TRIBEL', M. M., Institute of Chemical Physics,  
USSR Academy of Sciences

[Abstract] The paper considers the possibility of investigation of unbalanced spin processes in biological and model systems going through an intermediate state, which consists of pairs of paramagnetic particles. Such, for example, as ion radicals. The necessity for inclusion of model systems, among which not the last place is occupied by molecular crystals and organic semiconductors, is caused by complex processes which precede even in the simplest biological objects. Any photobiological process is a succession of various stages, differing in their nature and requiring a change of the investigation procedures. Certain primary physical and chemical processes are considered in the paper which are directly connected with absorption of light. In spite of the large variety of photobiological reactions all of them are more or less characterized by a common series of stages. The following items are discussed: 1) Primary photoprocesses; 2) Magnetic spin effects; 3) Spin effects in solid layers of chlorophyll; 4) Spin effect in chlorophyll solutions; 5) Spin effects in reaction centers of photosynthesizing organisms; and 6) Spin effects during photosynthesis in vivo. It is shown that evolution of spin pairs depends on the interior and exterior fields, and appears in magnetic effects on photoconductivity or fluorescence of both model or real photosynthesizing systems. Figures 7; references 13: 7 Russian, 6 Western.  
[177-6415]

## SCHOTTKY BARRIERS AND THEIR USE FOR STUDYING PROPERTIES OF SEMICONDUCTORS

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 5 Feb 81) pp 3-19

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[Abstract] The basis of a Schottky diode is a metal-semiconductor structure with a potential barrier at the semiconductor surface (an m-s structure). The key advantage of m-s structures, as opposed to p-n structures, is that in their creation the properties of the original semiconductor do not change, chiefly because m-s structures are created at fairly low temperatures. This makes it possible to use these structures to study the properties of semiconductor materials. Schottky barriers are being used to study: 1) The energy distribution of charge carriers in a semiconductor, including the width of the forbidden band, the minimum energy of cross-over transitions and the energy distribution of surface states, 2) The behavior of impurities in a semiconductor, including the concentration of impurities, their ionization energy, the trapping cross section for an electron, hole or photon by an impurity center, and the center's photoionization cross section, and 3) The absorption of light and recombination of charge carriers in a semiconductor, including the light absorption coefficient and the diffusion and drift length of minority carriers. Schottky barriers are being used to study new materials, including compounds, solid solutions and variable-band semiconductors with energy bands which vary along the coordinates of their structure. The space charge layer present near the surface of the semiconductor in Schottky barriers can easily be varied in terms of its width and the strength of the electric field in it by means of biased voltage. It is thus possible to alter the charge and degree of ionization of impurity atoms and the width of the region for the gathering of nonequilibrium carriers which originate in the photoelectric effect. Many of the methods employed to measure the parameters of semiconductor materials are more accurate and simpler than traditional methods. The ability to employ direct nondestructive methods of measurement is a great advantage. For example, determination of the parameters of a band diagram by the Schottky barrier method is based on the fact that the photocurrent spectrum with small absorption coefficients is similar to the absorption spectrum. This method does not require making thin specimens, as in the traditional method based on measuring the transmittance of a semiconductor, but makes it possible to determine the width of the forbidden band directly in the semiconductor device and results in higher measurement accuracy because current can be measured more precisely than the intensity of light. The paper is based on the material of a lecture read by the author at the Second School On Microelectronics at Primorsko (Bulgaria) in June 1979. Figures 8; references 70: 27 Russian, 43 Western.

[210-8831]

## PHOTOMEMORY ON METAL-SEMICONDUCTOR JUNCTION USING GeSe SINGLE CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 1 Jul 80) pp 385-389

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[Abstract] Luminous nonequilibrium straightening of energy bands and recovery of the potential barrier at room temperature was studied in high-resistivity Schottky-barrier GeSe single crystals with low concentration of surface electron states. A semitranslucent aluminum layer deposited on the fresh surface of  $2 \times 2$ - $4 \times 4$  mm<sup>2</sup> large and 50-200 micrometer thick p-GeSe single crystals formed the straightening barrier. A flash from an ISSh-100 3M lamp of 3 microsecond duration and  $10^{18}$  quanta/cm<sup>2</sup>·s maximum intensity served as excitation. The height of the barrier was found to decrease exponentially during illumination, with the time constant inversely proportional to the light intensity, and to recover slowly nonexponentially after illumination. A forward bias applied at the end of the light pulse causes relaxation of the barrier to a quasi-equilibrium height. It will also erase the photomemory when applied at a later time. Figures 3; tables 1; references 18: 17 Russian, 1 Western.  
[249-2415]

## LUMINESCENCE OF NITROGENOUS IMPURITY-DEFECT COMPLEXES IN ION-IMPLANTATION LAYERS OF NATURAL DIAMOND

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 11 Mar 81) pp 397-403

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[Abstract] An experimental study was made, by the cathodoluminescence method, of diamond layers containing implanted nitrogen. Into lamina of natural diamond (grades IIa and Ia with fewer than  $10^{18}$  cm<sup>-3</sup>, respectively and at least  $10^{19}$  cm<sup>-3</sup> nitrogen atoms) were implanted at room temperature, in a High-Voltage Engineering Europa accelerator, nitrogen ions with energy up to 350 keV in doses designed to produce the appropriate impurity concentration profile. The specimens were then annealed in a graphite crucible for 2 h under a  $10^{-5}$  torr vacuum at temperatures from 500 to 1400°C. Cathodoluminescence was excited with a 2-10 keV electron beam at a current of 5 microampere and was analyzed at 80 K in the 300-900 micrometer range of the wavelength spectrum. Luminescence centers and corresponding lines



appeared as follows: 389 and 441.5 nm immediately after implantation, 575 nm after annealing at  $T > 500^{\circ}\text{C}$ , 415 and 503 nm after annealing at  $T > 1000^{\circ}\text{C}$ , while 389 and 441.5 nm vanished, 439 and 539 nm after annealing at  $T \sim 1400^{\circ}\text{C}$ . The data on the dependence of the line intensities on the implantation dose and the annealing temperature yield new information about the microstructure of nitrogen-complex centers and their "softness" as well as their transformation. The authors thank A. V. Spitsyn and V. A. Dravin for performing the ion implantation, N. A. Shuvalova for annealing the specimens, and Ye. V. Sobolev and Ye. A. Konorova for discussing the results. Figures 5; references 26: 11 Russian, 15 Western. [249-2415]

UDC 621.315.592

# FORMATION, ANNEALING AND INTERACTION OF DEFECTS IN ION-IMPLANTATION LAYERS OF NATURAL DIAMOND

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82 (manuscript received 14 Mar 81) pp 404-411

GIPPIUS, A. A., ZAYTSEV, A. M. and VAVILOV, V. S., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] An experimental study was made by the cathodoluminescence method of defects in ion-implantation layers of diamond. Into crystals of natural diamond (grades IIa and Ia with, respectively, fewer than  $10^{18} \text{ cm}^{-3}$  and at least  $10^{19} \text{ cm}^{-3}$  nitrogen atoms) 30-350 keV ions in  $10^{11}$ - $10^{15} \text{ cm}^{-2}$  doses in a High Voltage Engineering Europa heavy-ion accelerator. The specimens were then annealed in a graphite crucible for 2 h under a  $10^{-5}$  torr vacuum at  $150$ - $1400^{\circ}\text{C}$ . Some specimens were bombarded with 2.2 MeV or 10 keV electrons for subthreshold defect formation. Cathodoluminescence was excited with a 2-20 keV electron beam at a current of 5 microampere and analyzed at 80 K in the 300-900 nm range of the wavelength spectrum. In the unannealed state after implantation, defects were found not to depend on the one controlling impurity (nitrogen) but the spectral lines were found to depend on the kind of implanted ions ( $\text{H}^+$ ,  $\text{C}^+$ ,  $\text{N}^+$ ). The data on quenching and intensification of luminescence lines, on interaction of defects and their annealing as well as on the effect of surrounding defects on the annealing of luminescence centers, especially in layers with large implantation dose, reveal a definite role of nitrogen and confirm the concept of disordered domains. The authors thank A. V. Spitsyn and V. A. Dravin for performing the ion implantation, N. A. Shuvalova for annealing the specimens, Ye. A. Konorova and V. V. Krasnopevtsev for their valuable comments and discussion of the results. Figures 8; references 22: 8 Russian, 14 Western. [249-2415]

## MANIFESTATION OF RESIDUAL IMPURITIES IN PURE GERMANIUM DURING GAMMA-IRRADIATION

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 15 May 81) pp 458-460

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[Abstract] Fast-diffusing impurities in germanium crystals can, upon heat treatment or irradiation, change from the inactive state to the electrically active state and thus affect the reliability of germanium detectors. "Activation" of copper impurity by irradiation from a  $\text{Co}^{60}$  source was experimentally studied in pure and extra-pure germanium single crystals with concentrations of charge carriers  $10^{12}$ - $10^{13} \text{ cm}^{-3}$  and at most  $10^{11} \text{ cm}^{-3}$ , respectively. Electrical measurements at 4.2-300 K before irradiation revealed a predominance of aluminum (rarely gallium) in p-type crystals and of phosphorous (rarely arsenic) in n-type crystals. The concentration of  $E_v + 0.043 \text{ eV}$  impurity centers caused by substituting copper atoms could be determined after irradiation: in p-type crystals directly from the temperature dependence of the hole concentration over the 20-100 K range, in p-type crystals only indirectly from the total concentration of compensating acceptors with acceptor and donor concentrations determined separately. After complete activation the concentration of active copper atoms was not higher than  $5 \cdot 10^{11} \text{ cm}^{-3}$  (pure) and  $10^{11} \text{ cm}^{-3}$  (extra-pure) in p-type crystals and as much as  $(2-4) \cdot 10^{12} \text{ cm}^{-3}$  in the acceptor state in n-type crystals. The authors thank E. E. Haller for supplying the extra-pure specimens from the Lawrence Laboratory at the University of California. Figures 1; tables 2; references 11: 5 Russian, 6 Western (one in translation). [249-2415]

## CHAIN PROCESS OF DEFECT ANNIHILATION IN SEMICONDUCTOR CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 16 Dec 80, after final editing 12 Aug 81) pp 480-484

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[Abstract] Acceleration of the defect annihilation process in silicon and GaAs crystals is analyzed on the basis of the energy dissipation model. The mean probability of excitation of electron-hole states during annihilation of a Frenkel pair is described by the Landau-Einer equation and an annihilation domain is regarded as a source of elastic vibrations causing the crystal

to heat up. Available data on the low-temperature behavior are extrapolated to very high annihilation temperatures, using a nonlinear equation of heat conduction with a variable thermal conductivity and the equation of defect (Frenkel pair) annihilation with or without diffusion taken into account. The solution yields a threshold defect density at which chain annihilation of Frenkel pairs will begin. This can occur in crystals with a sufficiently high energy of atom displacement into interstices, a low annihilation barrier, and an anomalously high frequency of transitions. Figures 2; references 14: 7 Russian, 7 Western.  
[249-2415]

UDC 621.315.592

EFFECT OF STRONG ELECTRIC FIELD ON EXCITON ABSORPTION SPECTRUM IN GaP CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82 (manuscript received 6 Mar 81, after final editing 20 Aug 81) pp 485-491

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[Abstract] The spectrum of electroabsorption in GaP crystals near the indirect threshold is analyzed, taking into account the intricacy of exciton bands. Calculations are based on the equation of effective mass. The probability of indirect optical exciton transitions in the multiband model is calculated, assuming a two-particle exciton state and including electron-photon as well as electron-phonon interaction. In the specific case of GaP one needs to consider only virtual states, with smallest energy gaps and allowed transitions in the first order, one can also assume a complete wave function. On this basis, in the spherical approximation, the Schroedinger equation is solved for an indirect exciton in an electric field. Separation of variables is possible in a parabolic system of coordinates. Results for the state with the magnetic quantum  $m = 0$  in strong electric fields, up to  $10^4$  V/cm, have been obtained by numerical solution. They agree closely with experimental data on electroabsorption at 4.2 K in GaP near the threshold of LA-phonon emission. The author thanks B. N. Shalaye and A. I. Sokolov for discussing several of the problems here, also I. I. Parfenov for assisting with computations. Figures 4; references 19: 12 Russian, 7 Western.  
[249-2415]

## TELLURIUM-DOPED GaSb CRYSTALS UNDER HYDROSTATIC PRESSURE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 20 Nov 80) pp 492-493

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[Abstract] The pressure dependence of the Hall coefficient was measured on four specimens of GaSb crystals doped with tellurium to free-electron concentrations within the  $(8.7 \cdot 10^{17} - 1.45 \cdot 10^{18}) \text{ cm}^{-3}$  range. As the hydrostatic pressure increases, the Hall coefficient increases to a maximum at approximately 8 kbar in each case and then decreases until above 10 kbar it becomes smaller than at atmospheric pressure. This saturation at high pressures is explained by congregation of all electrons in L-valleys, while at atmospheric pressure there are electrons in L- and  $\Delta$ -valleys. On the basis of these data is calculated the dependence of the Hall coefficient on the L-electron concentration, also the distance between L- and  $\Delta$ -valleys at atmospheric pressure as well as the rate at which L- and  $\Delta$ -peaks come closer together with increasing pressure. Figures 1; tables 1; references 3: 2 Russian, 1 Western.

[249-2415]

## DISPERSION RELATION FOR PIEZO-OPTICAL CONSTANTS OF GaAs AND GaP

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3,  
Mar 82 (manuscript received 11 May 81) pp 503-505

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[Abstract] The dispersion relation  $C(\omega)$  for the piezo-optical constants of GaAs and GaP near the edge of intrinsic absorption is calculated without the aid of curve fitting additional parameters on the basis of a semiempirical model in a linear approximation, with respect to mechanical stresses, for  $\text{AIIIbV}$  compounds with a sphaleritic structure. The strain potential constant for interband optical transitions is calculated from experimental data on GaAs and GaP as well as on AlSb, GaAs, InSb and InP. The dispersion parameters  $\langle A \rangle$  and  $G_1$  are calculated from data on dispersion of longitudinal and transverse refractive index in  $\text{AIIIbV}$  compounds. The dispersion of the piezo-optical constants is also measured in high-resistivity single crystals at 297 K. Figures 1; references 8: 3 Russian, 5 Western.

[249-2415]

## EFFICIENCY OF RADIATIVE ACTION OF 3-1000 MeV ELECTRONS ON SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3,  
Mar 82 (manuscript received 5 Nov 80, after final editing 3 Jun 81)  
pp 513-516

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[Abstract] The behavior of semiconductor materials in radiation fields depends on the efficiency of radiative action, particularly by relativistic electrons. The lifetime of excess charge carriers is most sensitive to the concentration of induced defects, the change in the reciprocal of this lifetime being proportional to the cumulative radiation dose. The proportionality factor or coefficient of radiative defectiveness has been measured by various methods applicable to narrow ranges of electron energy. Here this relation is measured for silicon with bombarding by 3-1000 MeV electrons at 300 K, in pulses of 0.5 microsecond duration with a repetition rate of 50 Hz. The lifetime of excess charge carriers is determined from the drop of photoconduction current pulses due to excitation by accelerated electrons, taking into account the dependence of this lifetime on the excitation intensity and its independence of the initial electron concentration in silicon below a threshold level. The experimental data are compared with calculations based on the model of elastic electron scattering by nuclei and on the Mott equation for the scattering cross section. As the energy of bombarding electrons increases above 100 MeV, the calculated defectiveness cross section remains constant but the measured efficiency of defect formation increases, probably because of attendant inelastic electron-nucleus interaction. The authors thank V. A. Yamnitskiy, A. M. Vaysfel'd and E. A. Reznichenko for assisting in the study and discussing the results. Figures 2; references 10: 9 Russian, 1 Western.  
[249-2415]

## INFRARED ABSORPTION BY RADIATIVE DEFECTS IN ALUMINUM-DOPED SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3,  
Mar 82 (manuscript received 13 Jul 81) pp 538-540

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[Abstract] The authors have detected 469, 431, 242  $\text{cm}^{-1}$  bands in the infrared absorption spectrum of silicon crystals doped with aluminum, the first two caused by vibrations of paired  $\text{Al}_2^-$  and the third one caused by vibrations of  $\text{Al}_1^{++}$ . Specimens of silicon crystals are doped with aluminum

or boron during the pulling process, to an initial electrical resistivity of approximately 0.02 ohm·cm, then irradiated with neutron fluxes of  $5 \cdot 10^{17}$  and  $10^{18}$  cm<sup>-2</sup> from a reactor. Measurements were made in the 2-25 micrometer range of wavelengths at 300, 80 and 20 K. The infrared absorption spectrum of Si < Al > differs from that of Si < B > by having new bands on the background of a much weaker 3.9 micrometer band and by not containing the 3.61 and 3.45 micrometer bands. In Si < Al > absorption near the edge of the dominant band increases sharply after isochronous annealing at 250°C and absorption by free charge carriers occurs after annealing of disorder domains at 350°C. Figures 1; references 6: all Western.  
[249-2415]

UDC 621.315.59

# STRUCTURE AND DIMENSIONS OF DEFECT-BUILDUP REGION IN PROTON-IRRADIATED N-TYPE SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82 (manuscript received 8 Apr 81, after final editing 2 Aug 81) pp 542-546

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[Abstract] A study is made of the defect-buildup region in silicon irradiated with protons. Specimens of weakly compensated n-type crystals with an initial electrical resistivity of 3-500 ohm·cm are pulled by the Czochralski method and by zone refining with oxygen concentrations  $\approx 8 \cdot 10^{17}$  cm<sup>-3</sup> and  $\lesssim 10^{16}$  cm<sup>-3</sup>, respectively. They are irradiated with 660 MeV protons at  $T \lesssim 50^\circ\text{C}$  and, for comparison, with gamma quanta from a Co<sup>60</sup> source. The temperature dependence of the Hall coefficient is then measured over the 78-400 K range. On the basis of these measurements the temperature dependence of the charge carrier concentration in irradiated specimens and the energy bands are determined. From experimental data and by calculations based on the Poisson equation the dimensions of the radiative defect-buildup region are now determined, assuming this region to be spherical, i.e., the average radius  $r_1$  of its E-centers core (ionization of vacancies) and the average width  $r_2$  of its A-centers envelope (impurity defects). In both kinds of crystals  $r_2 > r_1$ . As the initial donor concentration  $n_0$  increases, over the  $10^{13}$ - $10^{15}$  cm<sup>-3</sup> range,  $r_1$  remains almost constant in pulled crystals and decreases in zone refined crystals. In both kinds of crystals  $r_2$  does not depend on  $n_0$ , but it is approximately twice as large in zone refined ones as in pulled ones. Annealing of defects is found to occur in one stage in pulled crystals (320-380°C) but in two stages in zone refined crystals (250-300°C and 320-380°C). Figures 3; references 13: 8 Russian, 5 Western.  
[249-2415]

## TENSOELECTRIC EFFECTS IN IRRADIATED SCHOTTKY-BARRIER GaAs DIODES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 24 Feb 81, after final editing 12 Aug 81) pp 546-548

VYATKIN, A. P., MAKSIMOVA, N. K. and FILONOV, N. G., Siberian Physico-Technical Institute imeni V. D. Kuznetsov, Tomsk State University, Tomsk

[Abstract] An experimental study is made to determine the effect of radiative defects caused by irradiating high-energy electrons on the sensitivity of Schottky-barrier GaAs diodes to deformation (pressure). Specimens of Pd-GaAs structures with rectifying junctions are electrodeposited of n-GaAs with a charge carrier concentration  $n_0 \sim 1 \cdot 10^{16} \text{ cm}^{-3}$  on wafers with a (100) orientation. The defect concentration is varied by increasing the irradiation dose:  $(3,6,8) \cdot 10^{15} \text{ cm}^{-2}$ . Hydrostatic pressure up to 5.5 kbar is applied to the specimens in a special chamber with transformer oil. The height of the rectifying potential barrier is determined from the current-voltage characteristics, the relative tensosensitivity is calculated for various forward and reverse bias voltages. Before irradiation the tensosensitivity of both forward and reverse current is independent of the bias voltage. After irradiation the tensosensitivity of both currents is lower and depends on the bias voltage in an intricate manner determined by the degree of compensation, which increases with increasing irradiation dose, and by the correspondingly increasing probability of resonant electron tunneling in addition to regular thermoelectron emission. Figures 9; references 9: 6 Russian, 3 Western.  
[249-2415]

## EFFECT OF NEUTRON IRRADIATION ON MAGNETIC SUSCEPTIBILITY OF SILICON CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 9 Dec 80, after final editing 18 Sep 81) pp 560-562

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[Abstract] Measurement of magnetic susceptibility was used for study of defects produced in silicon crystals by transmutational doping through irradiation with thermal neutrons. Two groups of p-Si single crystals are grown by the Czochralski method, with initial hole concentrations of  $4 \cdot 10^{15}$  and  $2 \cdot 10^{16} \text{ cm}^{-3}$ , respectively, with a hole mobility of 300-400 cm/V.s and dislocation density of  $10^4 \text{ cm}^{-2}$  in both. All specimens were irradiated with thermal neutrons (2.5% fast neutrons) from a reactor in doses of  $2 \cdot 10^{19}$  and  $9 \cdot 10^{20} \text{ cm}^{-2}$  respectively. The magnetic susceptibility is measured

by the Faraday method at room temperature. It is found to be independent of the magnetic field intensity, but to decrease after irradiation slightly (2-3%) in the first group and appreciably (10-15%) in the second group. Isochronous annealing for 20 min at temperatures up to 800°C caused the diamagnetism of irradiated crystals in both groups to increase and their magnetic susceptibility to become field dependent. This indicates a paramagnetic nature of radiative defects, which is further confirmed by a residual paramagnetism and a residual weak field dependence after annealing at 800°C. Some radiative defects remain unannealed at this temperature, as in the case of "oxygenous" silicon. Figures 2; references 6: 4 Russian, 2 Western. [249-2415]

UDC 621.315.592

#### EFFECT OF INDIUM ON ELECTRICAL PROPERTIES OF GaAs SINGLE CRYSTALS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82 (manuscript received 25 Sep 81) pp 566-568

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[Abstract] A study is made of the electrical properties of GaAs single crystals doped with isovalent indium. The specimens are grown by the Czochralski method in a flux bed. The doping impurity is injected as the InAs compound, with the concentration of indium atoms varying from  $7 \cdot 10^{19}$  to  $5 \cdot 10^{21} \text{ cm}^{-3}$ . The electrical resistivity is found to remain high ( $10^7$ - $10^9 \text{ ohm} \cdot \text{cm}$ ) over a wide range of indium concentrations ( $2 \cdot 10^{19}$ - $2 \cdot 10^{20} \text{ cm}^{-3}$ ), while the electron mobility varies from 2600 to 7000  $\text{cm}^2/\text{V} \cdot \text{s}$ . It remains high after annealing at 900°C in a hydrogen atmosphere or in sulfur vapor, indicating a high thermal stability of the material. It drops sharply at indium concentrations below  $2 \cdot 10^{19} \text{ cm}^{-3}$  and above  $2 \cdot 10^{20} \text{ cm}^{-3}$ . The temperature dependence of the electron concentration and of the Hall effect in high-resistivity GaAs doped by In is also measured. The dislocation density is found to be minimum in GaAs crystals with indium concentrations of  $(2-5) \cdot 10^{19} \text{ cm}^{-3}$ , higher concentrations resulting in impurity inhomogeneities. The lattice period obeys the Vegard law without anomalies and, therefore, no additional defects form caused by breakup of super-saturated solid solution of excess gallium. The authors thank S. P. Grishina for performing the heat treatment and measuring the dislocation density. Figures 2; tables 1; references 5: 3 Russian, 2 Western. [249-2415]



## PROPERTIES OF NICKEL-DOPED SILICON UNDER LARGE DOSES OF GAMMA-IRRADIATION

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 16, No 3, Mar 82  
(manuscript received 9 Jun 81, after final editing 8 Oct 81) pp 574-575

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[Abstract] The behavior of neutral nickel impurity in silicon under large doses of gamma irradiation is studied in both p-type and n-type silicon with an electrical resistivity of 40-200 ohm·cm. Layers of metallic nickel are deposited at 1000-1250°C in an argon atmosphere. The specimens are then irradiated in air at not more than 100°C from a Co<sup>60</sup> source with an intensity of  $3 \cdot 10^3$  R/s. The results reveal that p-type crystals remain and n-type crystal become p-type ones after irradiation, the hole concentration increasing as the nickel concentration increases. The temperature dependence of the Hall effect and the photoconduction spectra reveal unambiguously that heavy irradiation does not produce new levels but increases the concentration of electrically active nickel atoms which produce  $E_c - 0.2$  and  $E_c - 0.4$  eV acceptor levels in silicon. Annealing at 450-500°C for several hours restores the initial electrical properties of irradiated silicon but does not change the electrical properties of irradiated Si<Ni>.

References: 2 Russian,

[249-2415]

## APPROXIMATE METHOD OF THEORETICALLY SIMULATING ION IMPLANTATION

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 15 May 81) pp 134-137

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[Abstract] Simulating ion implantation into a semiconductor theoretically is an economical way to predetermine the process conditions which will yield the necessary properties of the doped region. One approximate method of simulating the ion concentration profile is evaluating the integral in the profile equation by way of the steepest descent and the use of a corresponding exponential kernel, for determination of the ion path and straggle. Results are shown for polyenergetical ions of five kinds (B, P, S, As, Sb) in four different target materials (Si<sub>3</sub>N<sub>4</sub>, SiO<sub>2</sub>, Si, GaAs). The results are also compared with those obtained by numerical integration. The method is applied to the typical case of a step profile. Figures 3; tables 1; references 8: 4 Russian, 4 Western.

[250-2415]

## POSSIBILITIES, LIMITATIONS AND PROBLEMS IN DEVELOPMENT OF PLANAR WAVEGUIDE OPTICS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOELEKTRONIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 17 Aug 81) pp 4-20

DERYUGIN, L. N.

[Abstract] A review is presented of achievements and limitations discovered in planar waveguide optics over its 15-year development history. Problems facing planar waveguide optics today and possible ways of solving them are discussed. The key advantages of planar waveguide optics over traditional 3-dimensional optics are discussed, as well as the new potential capabilities which this field has revealed for the creation of optoelectronic integrated circuits. The field of planar optics is occupied with questions relating to the generation, propagation, conversion and reception of light in planar optical waveguides and with the application of these waveguides in optical devices. The subject of planar optics is light flux concentrated in very thin film-type waveguides formed by means of an insulator or semiconductor layer having a refractive index greater than that of the substrate supporting it. It is possible to construct film-type planar analogues of all the basic elements of 3-dimensional optics, because sections of planar waveguides having a specific configuration and being made of the appropriate materials can perform the functions of optical and optoelectronic elements and units. It is possible to create optical waveguide circuits which are similar to microwave circuits. The limitations of planar optics are caused by the fact that optical radiation is confined to a thin waveguide layer in which it repeatedly interacts with the material and boundaries of the layer. These limitations are associated with the 2-dimensional nature of planar optics, optical losses, spatial noise, spatial phase fluctuations and the lack of a general-purpose material. Among the unsolved problems of planar optics are that of reducing spatial phase fluctuations, reducing optical losses from scattering in inhomogeneities and the spatial noise associated with them, and establishing optimum levels for the integration and hybridization of planar optical devices taking into account the real capabilities of materials and the technology. It is necessary to solve problems in effectively joining hybrid elements. The main problem here is effectively joining a laser radiation source with the remaining part of the integrated circuit. All these problems are basically of a technological nature and can be solved only by the realization of very high specifications with regard to the purity and homogeneity of the materials of films and substrates, cleanliness and uniformity in treating the surfaces and forming the boundaries of planar elements, accuracy in reproducing the dimensions and parameters of elements and accuracy in arranging and interfacing hybrid elements. Integrated optics at the present time has borrowed its technological methods chiefly from microelectronics and 3-dimensional optics, but these methods in a number of instances do not satisfy the stricter specifications of integrated optics. Figures 9; references 49:

39 Russian, 10 Western.

[218-8831]

## PHOTOELECTRIC AMPLIFIER OF NANOSECOND PULSES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 82  
(manuscript received 14 Nov 80) pp 60-61

AVER'YANOV, G. A., SAVICHEV, B. M. and PROSHINA, V. S.

[Abstract] A wideband photoelectric amplifier has been developed for 10 ns optical pulses with repetition rates up to 50 MHz. The input stage includes a LFD-2 photodiode, with a KP303G field-effect transistor and a KT368 bipolar transistor in the common-emitter common-collector connection. There follow an i-f stage and an h-f stage, both built with 228UV2 microcircuits, a 2-Kohm potentiometer in the i-f stage included for gain control. The nominal gain is 200, with a 20 dB regulation. The output stage, matched to the h-f stage through an emitter follower with a KT363B high-frequency p-n-p transistor, consists of two such KT363B transistors in parallel. Nonlinear distortion is minimized by raising the supply voltage to +8.0 V from the conventional +6.3 V across the microcircuits at full load. All components, including conventional radioelectrical elements (resistors, capacitors, diodes), are mounted on one side of a bilaterally clad 150x50 mm<sup>2</sup> large and 1.5 mm thick glass-Textolite printed-circuit board with the other side grounded. The amplifier can handle input pulses with amplitudes up to 4.0 V, its noise level referred to the input is 40-50 microvolt. It operates with a 75-ohm matching cable, but can also operate with a 60-ohm matching cable to the load at a signal level reduced to 67%. Figures 1; references: 3 Russian.  
[241-2415]

## DIFFRACTION METHODS FOR DETERMINING SPREAD OF LINEAR DIMENSIONS OF TOPOLOGY ELEMENTS OF LARGE INTEGRATED CIRCUITS

Moscow MIKROELEKTRONIKA in Russian Vol 10, No 6, Nov-Dec 81  
(manuscript received 8 Aug 80) pp 523-529

KAPAYEV, V. V.

[Abstract] With the increase in the degree of integration, the requirements on the precision of fulfillment of the dimensions of microcircuit elements have increased considerably. In this connection the necessity arises to check not only reproduction of the dimensions of elements on wafers, but also the spread of dimensions within an individual crystal, because the magnitude of this spread precisely determines the probability of fitness for work of the circuit arranged on the crystal in question. In order to evaluate the spread it is necessary to perform a number of measurements on one crystal. The present work theoretically shows that a diffraction grating

is a suitable test object which makes it possible simultaneously to measure the mean value and the spread of the linear dimensions of the elements of the microcircuits. With a sufficiently large number of rules in the grating, the intensity of light diffraction in the direction of the principal maximums weakly depends on the concrete form of distortion of the regular structure of the grating, determined basically by the magnitude of the deviation of the dimensions from the mean value. Figures 2; references 3: 2 Russian, 1 Western in translation.  
[137-A-6415]

UDC 621.382

#### INVESTIGATION OF VOLT-AMPERE CHARACTERISTICS OF MIS STRUCTURE BASED ON GaAs

Moscow MIKROELEKTRONIKA in Russian Vol 10, No 6, Nov-Dec 81  
(manuscript received 6 Jan 81) pp 545-548

DMITRUK, N. L., ZYUGANOV, A. N. and MAYEVA, O. I., Institute of Semiconductors, UkSSR Academy of Sciences

[Abstract] The present brief communication is devoted to an investigation of the electrical conductivity of thin ( $\sim 10^{-5}$  cm) dielectric layers of  $\text{Ge}_3\text{N}_4$  entering into a metal-insulator-semiconductor [MIS] structure based on GaAs, which is promising for creation of a whole series of microelectronic devices. The method of obtaining layers of  $\text{Ge}_3\text{N}_4$  is explained. The volt-ampere characteristics of the structure In-GaAs- $\text{Ge}_3\text{N}_4$ -Al were obtained at room temperature ( $T \sim 300^\circ\text{C}$ ) at forward (plus at Al) and reverse (plus at In) biases. Some of these characteristics are presented in Figure 1 of the text. Domination of the mechanism of current limitation by a space charge, localized mainly at deep-seated (0.8 eV) levels with a high ( $10^{17} \text{ cm}^{-3}$  with  $\epsilon \sim 10$ ) concentration is shown. Figures 2; tables 1; references 13: 11 Russian, 2 Western.  
[137-A-6415]

## FEATURES OF CHARGE GENERATION IN CHARGE-COUPLED DEVICE WITH MACROSCOPIC DEFECTS

Moscow MIKROELEKTRONIKA in Russian Vol 10, No 6, Nov-Dec 81  
(manuscript received 2 Jun 80) pp 549-552

KLYAUS, Kh. I., SEVAST'YANOV, S. B., SERDYUK, Yu. N. and CHEREPOV, Ye. I.,  
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[Abstract] The present brief communication considers some special features of the process of thermal generation in charge-coupled devices [CCD] which have macroscopic defective sections comparable in their dimensions with the dimensions of a metal-insulator-semiconductor cell. These special features can appear in the form of anomalously high rates of charge generation and peaks at the generation curve  $dQ_p/dt$ . The investigations were conducted on three-phase 64-digit CCD-shift registers, fulfilled on the basis of structure of semiSilicon-Si<sub>3</sub>N<sub>4</sub>(700 Å)-SiO<sub>2</sub>(1200 Å)-Si (KEF-7.5) [100] with the length of the transmitting electrode of ~13.5 micrometer and a clearance between them of ~1.5 micron. It is shown that the presence of anomalous cells correlates with the occurrence in the substrate of macroscopic defective sections with an increasing degree of doping, formed as the result of nonqualitative processing of the initial wafers. Some special features of the generation process in CCD-cells with heterogeneous parameters are considered. Figures 4; references 12: 9 Russian, 3 Western.  
[137-A-6415]

## CHARACTERISTICS OF MICROWAVE MIXERS BASED ON SCHOTTKY BARRIER DIODES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 6 Apr 81) pp 64-69

PETROV, G. V., Engineering Physics, Institute, Moscow

[Abstract] Schottky barrier diodes are the basic elements of any microwave mixer and exert considerable influence on its output characteristics. Because there is a considerable variation in the parameters of all semiconductor devices, considerable difficulties originate in determining their parameters in the development of mixers. Computer simulation must be employed instead of experimental modeling. A study is presented here of the frequency characteristics of Schottky diodes and of mixers based on them and of methods of studying these characteristics. Diodes based on GaAs surpass by approximately an order of magnitude in terms of maximum operating frequencies diodes based on Si. When GaAs diodes are used in wideband mixers the mixer's noise factor drops by 1 dB as compared with using Si diodes.

Si Schottky diodes have definite advantages when there are limitations on the power of the local oscillator. The equivalent circuit is presented which is used to determine the characteristics of a mixer and includes the circuit of the local oscillator and the equivalent circuit of the diode. The local oscillator is a voltage generator with a frequency-independent output impedance. The admittance of the Schottky diode is found and on its basis a determination is made of coefficients of the conductance matrix which relate low-signal currents and voltages in the mixer. In order to calculate a mixer's parameters a determination is first made of the frequency dependences of the diode's admittance, the voltage standing wave ratio, and the rectified current. Curves are shown, illustrating the dependence of the first-harmonic input conductance on frequency for Schottky diodes based on Si and GaAs. It is shown that the magnitude of the rectified current is higher for a GaAs Schottky diode than for a silicon. In designing Schottky diodes it is necessary to strive to reduce the value of  $R_s$ , representing the resistance of the linear section of the diode's equivalent circuit.  $R_s$  reduces the rectified current. By using the equivalent circuit presented for a Schottky diode, it is possible to determine the influence of variation in the parameters of a diode on its characteristics. It is shown that in the 6 to 12 GHz frequency band the parameters of mixers using silicon Schottky diodes are somewhat worse than those using GaAs diodes. This factor is compensated, however, by the fact that it is simpler to fabricate silicon diodes and their reliability is better than that of GaAs diodes. Silicon Schottky diodes are to be preferred when the power of the local oscillator is restricted. Figures 6; references 9: 8 Russian, 1 Western.

[210-8831]

UDC 621.382

#### PHOTOELECTROMOTIVE FORCE BARRIERS OF HgCdTe MOS STRUCTURES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 25 Feb 81) pp 70-73

ANTONOV, V. V., VOYTSEKHOVSKIY, A. V., KAZAK, Ye. P., LANSKAYA, O. G. and PLOMIPU, B. G., Siberian Physicotechnical Institute

[Abstract] The results are given of a study of the production of MOS (metal oxide semiconductor) structures based on the compound HgCdTe with an anode oxide film, and of their photoelectric properties, i.e., the dependence of the barrier photoelectromotive force on the bias voltage in the field-effect electrode and on the temperature. The surface of n- and p-type chips with random orientation was anodized after chemical treatment in an electrolyte consisting of a 0.1 N solution of KOH in ethylene glycol. MOS structures were produced by spraying semitransparent  $N_1$ -electrodes  $0.5 \times 0.25 \text{ mm}^2$  through a metallic mask onto an anode oxide film of HgCdTe. Capacitance-voltage characteristics of the MOS structures were obtained with

a test signal amplitude of approximately 3 mV at an operating temperature of 80 °K. Curves are shown, illustrating the dependence of the photo-e.m.f. and capacitance on the bias voltage in the field-effect electrode with incident radiation with wavelength of 3.39 microns for various specimens. The photoelectric characteristics of MOS structures based on HgCdTe were studied for optical radiation wavelengths of 1.15, 3.39 and 10.6 microns at a modulation frequency of approximately 1.5 kHz at an operating temperature of approximately 80 °K. The photo-e.m.f. signal was amplified by a low-noise amplifier with a high-impedance input (approximately 1 M $\Omega$ ), an approximately 200 kHz transmission band and gain of approximately  $10^3$ , and the barrier photo-e.m.f. was measured with a low level of photoexcitation. The dependence of the barrier photo-e.m.f. on temperature is shown for a structure fabricated from p-HgCdTe with a depletion bend in regions on the surface with a bias voltage in the field-effect electrode of zero. With an increase in operating temperature the concentration of electrons increases, resulting in a change in the position of the Fermi level, which moves toward the conduction band. With this the surface changes from a state of depletion to inversion and the value of the photo-e.m.f. increases when the temperature is equal to or greater than 150 °K. The photo-e.m.f. drops suddenly on account of the formation of an enriching bend in regions on the surface at equal to or greater than 230 °K when the semiconductor in the surface region acquires n-type conduction. Passivation with an anode oxide apparently reduces the recombination rate on the semiconductor's surface. The spectral characteristics of the photoconductivity of MOS structures based on HgCdTe have a smoother rise in the shortwave region than those of the starting chips. Figures 3; references 12: 5 Russian, 7 Western.  
[210-8831]

UDC 621.382.2

# ACTIVATION OF DOPING IMPURITY BY MEANS OF LASER RADIATION IN THIN SURFACE LAYERS OF OXIDIZED SILICON IMPLANTED WITH BORON IONS

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 26 Feb 80) pp 74-77

LYSENKO, V. S., NAZAROV, A. N. and LOKSHIN, M. M., Institute of Semiconductors, Ukrainian SSR Academy of Sciences

[Abstract] The results are given of a study of the influence of pulsed laser radiation on the process of activation of an ion-implanted boron impurity in Si-SiO<sub>2</sub> structures, as well as on the properties of SiO<sub>2</sub> films. A film of SiO<sub>2</sub> 1500 Å thick was grown at 1150 °C in an atmosphere of dry oxygen on n-Si specimens with resistivity of 4.5  $\Omega \cdot \text{cm}$ . B<sup>+</sup> ions with energy of 40 keV were implanted into the structure through the oxide film in a dose of  $1.25 \cdot 10^{12} \text{ cm}^{-2}$ , half of the wafer being covered with a shield to produce a control specimen. Sections measuring 0.5 cm<sup>2</sup> on the surfaces of the control and implanted specimens were exposed to the nonfocused

pulses of a Q-switched ruby laser with a pulse length of 50 ns and the strength of the incident radiation varying over the range of  $(0.9 \text{ to } 2.4) \cdot 10^7 \text{ W/cm}^2$ . The maximum in the distribution of the concentration of the introduced impurity was near the insulator-semiconductor interface. The heat-stimulated depolarization and high-frequency volt-farad characteristic methods were used to monitor the change in the electrophysical properties of the structures. Heat-stimulated depolarization measurements were made in the temperature range of 300 to 450 °K while heating linearly at a rate of 0.5 °K/s. It was found that the effect of the radiation of a ruby laser pulse with power of  $1.6 \cdot 10^7 \text{ W/cm}^2$  corresponds to thermal annealing for 20 min at 620 °C, and with power of  $2.3 \cdot 10^7 \text{ W/cm}^2$ , at a temperature of 730 °C. Laser irradiation results in a drop in the maximum capacitance of structures and in substantial lessening of the curvature of volt-farad characteristics. The effect of laser pulses results in considerable worsening of the electrophysical characteristics of the insulator. Responsible for worsening of the dielectric properties of  $\text{SiO}_2$  films in the original structures is the temperature gradient at the insulator-semiconductor interface, which originates in the absorption of laser radiation in the thin surface layer of silicon. If absorption in the  $\text{SiO}_2$  film is negligibly low and the temperature in a film approximately 1 micron thick reaches 1000 °C in approximately 100 ns, representing a state of thermal shock, this can result in thermomechanical stresses in the insulator-semiconductor interface and the formation of micropores and other imperfections in the insulator film. However, the influence of thermal shock here is reduced and partial annealing of defects in the insulator takes place because of the absorption of laser radiation in defects and in the introduced boron impurity in the oxide after implantation. Figures 3; references 11: 7 Russian, 4 Western. [210-8831]

UDC 621.382.2

## TWO-PROBE METHOD OF INVESTIGATION OF THYRISTOR TURN-ON PROCESS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 19 May 81) pp 109-119

KROGERIS, A. F., RASHEVITS, K. K. and SHINKA, Ya. K., Physics and Power  
Engineering Institute, LaSSR Academy of Sciences

[Abstract] In order to study the turn-on process in series-produced power transistors, the use is suggested of special probes which are widely used in electrical engineering for measurement of the distribution of current in massive conduction elements of electrical machines and equipment. The following items are considered in the present paper: 1) Basis of method of experimental determination of current-conduction region [CCR]; 2) Basic position of two-probe method; and 3) Investigation of process of extension of CCR in the thyristor structure. Experimental curves are plotted to show the variation in potential difference across a model and a



real thyristor. It is concluded that by means of an approximate theoretical analysis of the distribution of the current density in a thyristor structure, a connection is established between signals of the voltage measurable at the probes and the components of the current density in the anode part and the silicon plates of the structure. The results obtained are confirmed by a physical model of the structure. The possibility is shown of using the two-probe method for determining the location of the initial region of turn-on, the rate, the current density and the limits of extension of the CCR in the structures of power thyristors of industrial output with any form of anode current. Figures 6; references 7: 6 Russian, 1 Western. [177-6415]

UDC 621.382.2

#### LOW-FREQUENCY FLUCTUATIONS IN GaAs AVALANCHE TRANSIT TIME DIODE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 22 Apr 80) pp 1753-1759

KORNILOV, S. A. and PAVLOV, V. M.

[Abstract] An experimental investigation is made of a one flight-path gallium arsenide transit time diode oscillator [ATDO] with a Schottky barrier and a plane section of doping and a range of 10 GHz. The object of the investigation is to obtain information concerning a source of flicker noise and its effect on the oscillations generated. The authors conclude that the flicker component of the frequency fluctuations in a gallium arsenide ATDO with a uniform doping section does not result from modulation of the frequency by noise of the diode current. A source of flicker noise exists which directly influences the frequency of oscillations and appears comparatively weakly in the diode current. These concepts make it possible to develop a phenomenological model. In general outline, it accurately reflects the correlative connection of the frequency fluctuations and current in the ATDO. Additional investigations are necessary in order to determine the physical nature and localization of flicker noise. The authors thank E. A. Gel'vich, V. M. Val'd-Perlov and L. S. Sibirtsev for assistance in organizing the work. Figures 3; tables 2; references 7: 6 Russian, 1 Western. [88-6415]

## OBTAINING ELEMENTS OF SUBMICRON DIMENSIONS IN FILMS OF VARIOUS MATERIALS BY REACTIVE ION-BEAM ETCHING

Moscow MIKROELEKTRONIKA in Russian Vol 10, No 6, Nov-Dec 81  
(manuscript received 12 Dec 80) pp 494-499

KIREYEV, V. Yu., KUZNETSOVA, V. V., LAVRISHCHEV, V. P., MAKHOV, V. I.  
and YASTREBOV, V. G.

[Abstract] In order to evaluate the real possibilities of obtaining in a substrate, elements of submicron linear dimensions with specific geometrical parameters, it is necessary to have analytical dependences connecting these parameters with the angle of slope of the border of the elements in the mask and the selectivity of the etching process. The present work is devoted to the derivation of such analytical dependences as well as their experimental verification with the use of electron lithography at the stage of obtaining an image in the mask and reactive ion-beam etching during transfer of the image to the substrate surface. The basic theory and the experimental procedures are explained. It is concluded that theoretical consideration of the process of transfer of an image through a masking coating on the surface of a substrate by etching it by an accelerated stream of the ions of chemically active gases makes it possible to connect the geometrical parameters of the elements obtained (angle of slope of border), maintenance of linear dimensions with respect to the dimensions of the elements in the masking coating and the selectivity of the etching process. The reactive ion-beam etching gives a more favorable (monotonically decreasing) angular dependence of the rate of etching of the materials, from the point of view of obtaining elements of submicron linear dimensions, than does ion-beam etching. An experimental study of the process of obtaining elements of submicron linear dimensions with the use of electron-beam exposure (during formation of a design in the masking coating) and reactive ion-beam etching (during transfer of an image onto the surface of a substrate gave results which agree well with theory. The authors thank T. G. Nesterov and A. K. Kebirov for assistance in preparation of specimens. Figures 5; tables 1; references 10: 6 Russian, 4 Western. [137-A-6415]

## APPROXIMATE NONLINEAR ANALYSIS OF NOISE AMPLIFICATION IN O-TYPE TRAVELING-WAVE TUBE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 28 Mar 80) pp 1747-1752

LAZERSON, A. G. and MAN'KIN, I. A.

[Abstract] The paper is concerned with the development of an appropriate method for nonlinear analysis of noise amplification in a traveling-wave

tube [TWT]. The object of this is to clarify the basic regularity of the process as well as to obtain relatively simple analytical formulas, suitable for calculation of the characteristics of the noise at the output of the TWT. The authors conclude that the method developed for analysis of the amplification of a noise signal in a nonlinear regime makes it possible to obtain analytical formulas for a correlation function, and the spectral density of noise as a function of the parameters of a TWT. In contrast to earlier work described in the literature, the examination is conducted in time representation. This makes it possible to calculate the spectral density as a continuous function of the frequency. On the basis of the calculations illustrated it is shown that as the transition into a nonlinear regime proceeds, the bandwidth of the output of the TWT is expanded. It is necessary to take this into account during operation of a TWT in radio equipment. Figures 1; references: 7 Russian.  
[88-6415]

UDC 621.396.622.3

DIGITAL FREQUENCY SYNTHESIZER WITH SEQUENTIAL BALANCING

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 12 Mar 81) pp 40-42

ODINOKOV, V. F., Ryazan' Institute of Radio Engineering

[Abstract] Digital frequency synthesizers must feature a wide range of electronic tuning and high accuracy of frequency setting as well as stability and fast response of the automatic frequency control loop. These conflicting requirements can be largely reconciled by use of discrete electronic commutation (with diodes) of the frequency-setting elements (inductances) in the controlled oscillator and controlling this commutator, equivalent to a code-to-analog converter, in the frequency-tracking mode through sequential balancing of digits. Fine frequency setting is effected by means of phase-tracking automatic frequency control. Both frequency control loops are included in the structure of a digital frequency synthesizer, which also contains a variable-ratio divider, a time discriminator, a pulse-phase detector, and a reference oscillator with frequency divider. Transition from frequency-tracking mode to phase-tracking mode is effected with minimum duration of transients. The paper was recommended by the Department of Automated Control Systems. Figures 2; references: 6 Russian. [202-2415]

UDC 656.254:621.376.56"313"

OUTLOOK FOR DEVELOPMENT OF DIGITAL COMMUNICATION IN RAILROAD TRANSPORTATION SYSTEMS

Moscow AVTOMATIKA, TELEMEXHANIKA I SVYAZ' in Russian No 2, Feb 82 pp 12-15

NEYMAN, V. I., doctor of technical sciences

[Abstract] The only way to meet increasing demands for communication facilities with decreasingly available resources is through development of

new means of control and communication, which applies particularly to railroad transportation systems. Here innovation implies a changeover from analog to digital systems, specifically IKM (pulse code modulation) systems on account of their outstanding advantages. The major difficulties of such a changeover are those associated with coordinating the concurrent operation of both digital and analog equipment during the transition period, anticipated to be rather long. They include coping with interference between time-multiplexed and frequency-multiplexed signals in different conductor pairs in handling both systems. A technical-economic analysis indicates that installation of IKM-30 equipment in railroad transportation systems and operating it in accordance with ITTCC recommendations should be advantageous from the standpoint of both materials and energy consumption. These advantages can be pressed even further by use of fiber optics for transmission of digital signals. Figures 2.  
[200-2415]

UDC 681.3:656.257:621.398

#### SYSTEM USL-79 OF SEMAPHOR CONTROL FROM LOCOMOTIVE

Moscow AVTOMATIKA, TELEMEXHANIKA I SVYAZ' in Russian No 2, Feb 82 pp 5-9

KAZAKOV, A. A., acting professor, Moscow Institute of Railroad Engineers, KOSENKOV, N. S., candidate of technical sciences, SHALYAGIN, D. V., candidate of technical sciences, and LYUBIMOV, A. V., engineer

[Abstract] System USL-79 for semaphor control from a locomotive is relatively simple in construction and ensures execution of all necessary maneuvers in small railroad yards with a few locomotives, more efficiently than the TMML-75 system used in large railroad yards. It is designed to operate either with a centralized electrical system or with a centralized routing system. It is built with small-scale and medium-scale circuit integration, laid out on four printed-circuit boards. The stationary components mounted on a post include a master pulse generator, a frequency divider, three shift registers, an encoder, a transmitter, a receiver with another shift register, a code checking matrix, a decoder, and four control-command commutators. The first shift register is a distributor to 4 outputs, assembled on one K155IR1 microcircuit. The second shift register is a distributor to 8 outputs, assembled on two K155IR1 microcircuits with four inverters and one OR circuit (K155LA7). The third shift register is a distributor to 32 outputs, assembled on eight K155IR1 microcircuits. The encoder is assembled on three K155LA7 microcircuits with two NAND circuits each. The receiver register consists of eight D-triggers (K155TM2). The decoder is assembled on four K155LI1 microcircuits. The control-command commutators are assembled on K155LA7 microcircuits, the signal commutator is assembled on elements of K155LA3-K155LN1-K155LA3 microcircuits. The system enables a locomotive to control 32 two-position objects and to monitor their state. Figures 5.  
[200-2415]

## INSTRUMENTATION & MEASUREMENTS

UDC 535.512

### CEPSTRAL ANALYSIS AND SPECKLE INTERFEROMETRY OF BROADBAND IMAGES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 7 Apr 80) pp 271-277

AFRAYMOVICH, E. L.

[Abstract] Cepstral analysis has been developed as a basis for processing of broadband images such as those of large celestial objects, and for the purpose of compensating distortions after passage of optical signals through an unsteady nonhomogeneous atmosphere. It is an extension of speckle interferometry used for processing of images of bright objects such as stars with very small angular dimensions. It is also a variant of homomorphous filtration, namely nonlinear transformation of the product or convolution of signals into their sum, with possibility of subsequent linear filtration. Cepstrum is the spectrum of the logarithm of the signal power spectrum, which includes three components: coherent, noncoherent and noise. The algorithm of two-dimensional cepstral analysis includes two Fourier transformations with an intermediate logarithmic operation. Image restoration is possible, after filtration, through two inverse Fourier transformations with intermediate raising to a power. This technique can be useful for study of twin or multiple stars as well as for evaluation of image quality and telescope resolving power. Figures 3; references 12: 5 Russian, 7 Western.  
[199-2415]

UDC 621.3.03

### USING PECULIARITIES OF CONVOLVER OUTPUT SIGNALS FOR DETERMINING ARRIVAL TIME OF COMPLEX INPUT SIGNALS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 11 Jul 79) pp 27-29

KUZICHKIN, A. V., Leningrad

[Abstract] Operation of acoustic convolvers for radio engineering measurements, with countering ultrasonic analog of the input signal and ultrasonic

analog of the reference signal, is described and shown that it is possible to determine the arrival time of a complex input signal from the parameters of the output signal without search and synchronization procedures. The method is based on matching the convolver interaction range with the duration of the complex input signal, then using the correlation peaks of successive orders resulting from spatial coincidence of corresponding segments of input signal and reference signal. The method is demonstrated on two convolvers with a fixed time shift between their reference signals. Figures 1; tables 1; references: 3 Russian. [202-2415]

UDC 621.317

#### PERFORMANCE ANALYSIS OF A.C. PHOTOPOTENTIOMETERS

Moscow RADIOTEKHNIKA in Russian Vol 37, No 3, Mar 82  
(manuscript received after completion 3 Feb 81) pp 37-40

SKVORTSOV, B. V.

[Abstract] An a.c. photopotentiometer, a device consisting of a resistive film between two electrodes and connected to the collector through a photolayer, is described by an equivalent circuit with a diode in the light-probe region simulating the rectifier action of the junction between collector and illuminated photolayer. It is also described by a mathematical model in the one-dimensional approximation. The performance characteristics of this device are calculated on the basis of a linearized current-voltage characteristic of the photolayer capacitance. The theoretical output characteristics at various input frequencies as well as frequency, phase, and nonlinear distortion agree within 15% with experimental data. In order to reduce these distortions, it is necessary to select photopotentiometer materials which will yield a smaller photolayer capacitance and a linear current-voltage characteristic of the collector-photolayer junction. The author thanks A. G. Rokakh and L. D. Zorina of the Saratov State University for assisting in the preparation of photopotentiometer specimens. Figures 5; tables 1; references: 5 Russian. [203-2415]

## ONE POSSIBILITY OF MEASURING LOW FREQUENCIES FASTER

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 5 Mar 81) pp 15-17

SALAYEV, A. R., Azerbaijan Institute of Petroleum and Chemistry  
imeni M. Azizbekov

[Abstract] In order to increase the speed of frequency measurement, it is necessary to reduce the dynamic error. Here an algorithm of digital measurement of low frequencies is described which involves encoding the period and then subtracting a number  $N_T$  proportional to the period successively from a number corresponding to the maximum frequency of the range and to the required accuracy till a remainder is obtained. Afterwards this number  $N_T$  is iteratively converted to a number  $N_F$  proportional to the frequency, while the remainder is on each iteration shifted by one digit to the left, and then the value of the period code is subtracted from that remainder till a new remainder is obtained. The device for implementing this algorithm consists of several counters, including a counter-divider and a set of AND gates. The operation is illustrated on measurement of frequencies in the  $10^{-1}$ - $10^1$  Hz range within a 0.01% accuracy. The paper was recommended by the Department (Kafedra) of Information-Measurement and Computer Techniques. Figures 1; references: 1 Russian.  
[202-2415]

UDC 681.2

## ENTROPIC LATENCY OF EVENT

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 23 Feb 81) pp 3-7

KANEVSKIY, Z. M., Voronezh Polytechnic Institute

[Abstract] The concept of potential or entropic latency is defined as a quantitative measure of the difficulty in detecting an event or determining a quantity. It is characterized by the minimum number of binary measurements necessary to be made for disclosure. The concept and its application in engineering are illustrated for the typical case of flaw detection, where simultaneous events occur. Here all possible combinations of those events are represented in the form of a rectangular  $B \times A$  matrix with  $B = 2^A$  rows. Its probability characteristics are established, and on their basis the entropic efficiency of a measuring method or instrument as well as the cost (in labor or time) of a binary operation are derived. The paper was recommended by the Department (Kafedra) of Radio Engineering. Figures 2; references: 3 Russian.  
[202-2415]



'COMMUNICATION 81' EXHIBITION: MEASUREMENT TECHNIQUES

Moscow AVTOMATIKA, TELEMEXHANIKA I SVYAZ' in Russian No 2, Feb 82 pp 41-44

[Abstract] New instruments developed in the Soviet Union and shown at the International Exhibition "Communication 81" include voltmeters, oscillographs, electronic-counter frequency meters and signal generators for general or special applications, some with automation, also seven other devices: cable-embedment-depth meter, cable-insulation-fault locator, communication-cable router, crosstalk meter, automatic telephone-channel checker (net attenuation and psophometric noise), and generator-analyzer of logic signals for static and pulse testing.

[200-2415]

METHOD OF CONNECTING MAGNETORESISTIVE DOMAIN DETECTORS IN CYLINDRICAL-MAGNETIC-DOMAIN DEVICES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 4 Jan 81) pp 186-187

RAYEV, V. K. and SHORYGIN, M. P., Institute of Electronic Control Machines

[Abstract] The performance of a cylindrical-magnetic-domain device for data readout which consists of a herringbone expander and two magneto-resistive herringbone detectors depends largely on how the two detectors, main and compensating, are installed in the bridge circuit. If they are both in one domain displacement tracking channel one space period of the domain array apart ensures low interference caused by the unbalance between them. If the main detector is inside the channel and the compensating detector outside, recording of continuous domain sequences is facilitated. A scheme is now proposed which combines the advantages of both. The two detectors with an asymmetric topology are placed in the channel in a row and oriented with their detecting wings in opposition or, specifically, mirror-image position. Experimental data obtained with cylindrical-magnetic-domains 5 micrometer in diameter, a space period of 25 micrometer, and detectors consisting of 120 herringbones (thickness 0.4 micrometer, resistance about 320 ohm, current 4 mA) confirm the advantages of this scheme, when the sensors of the two detectors are separated by a distance equal to half the space period of the domain array or an odd multiple thereof. Figures 2; references 3: 1 Russian, 2 Western.  
[250-2415]

## DYNAMICS OF REORDERING OF STRUCTURE OF HETEROGENEOUS THERMO-OPTICAL MEDIUM

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82

(manuscript received 24 Dec 80) pp 30-39

KABYCHENKOV, A. F., Institute of Radio Engineering and Electronics,  
USSR Academy of Sciences

[Abstract] A theoretical study is presented of the motion of magnetic particles of micrometer dimensions in a viscous medium. The discussion is limited to paired interactions and the shape of the particles is approximated by prolate ellipsoids of revolution and it is assumed that the particles are magnetically anisotropic and that the easy axis is in line with the ellipsoid's major axis. It is also assumed that the particles interact with one another as point dipoles placed at the centers of spheroids, and that the magnetization vector is always directed along the effective field,  $H_{\text{eff}} = H + H_a + H_g$ , where  $H$  is the external field, which is generally inhomogeneous,  $H_a$  is the anisotropy field and  $H_g$  is the field of the neighboring particle. It is further assumed that the motion takes place in an infinite incompressible Newtonian fluid and that the axes of anisotropy and the magnetization vector and external field vector lie in the same plane. Lagrangian formalism is employed to derive equations of motion. The system's Lagrangian contains terms which define the kinetic energy of translational motion and rotation, the energy of uniaxial anisotropy, the energy of a particle in the external field, and the energy of magnetic dipole interaction. A system of equations is derived which describes motion representing the rotation of a particle to a position in which the axis of anisotropy is in line with the direction of the magnetic field and translational motion is along the direction of the field's growth. This study was prompted by the suggestion of a heterogeneous thermo-optical medium for recording information, based on a magnetic dispersed medium consisting of a transparent substance representing a binder capable of liquid-crystal aggregation transformation, and of a filler in the form of nontransparent magnetic particles. The particles are arranged chaotically in an unexposed heterogeneous medium and the medium is practically nontransparent. In order to record an optical signal the binder is transformed into the liquid state under the effect of radiation absorbed by the heterogeneous medium's particles and the magnetic particles are aligned into chains in the direction of an external magnetic field parallel to the incident light flux. The recorded image is fixed when the binder goes into the solid state. The theoretical study presented analyzes the process of recording in a heterogeneous medium of this sort. Figures 6; references 6: 3 Russian, 3 Western.

[210-8831]

UDC 539.293

TWO-DIMENSIONAL EFFECTS USED DURING SPACE CHARGE WAVES PROPAGATION IN THIN SEMICONDUCTOR FILMS FOR PROCESSING MICROWAVE SIGNALS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 5 May 80) pp 1765-1772

GUREVICH, G. L. and KOGAN, A. L.

[Abstract] Because of the rapid increase of the demand for devices used to process microwave signals, an investigation is of interest of physical phenomena, on the basis of which creation of new forms of such devices can be made. As shown in two previous papers (1979, 1980) by the authors, one of the promising directions for investigation is the use of two-dimensional effects during propagation of beams of waves of space charge [WSC] in thin semiconductor layers with drift electrons. In the present work a theoretical analysis is made of propagation in the units mentioned above of weakly polychromatic beams of WSC as well as consideration of the possibility of their use for space processing of frequency modulated microwave signals. A block diagram is presented of a device for processing microwave FM signals. The following items are considered in the work: 1) Green function for two-dimensional system in case of weakly polychromatic signal; 2) Space scanning of microwave radio signal in packet of space charge waves; 3) Selection of linearly frequency modulated signals of microwave band according to parameters of beams of WSC excitable by them; and 4) Limits of applicability of model. Figures 1; references: 2 Russian. [88-6415]

## PROPAGATION OF BEAMS THROUGH SMOOTHLY IRREGULAR WAVEGUIDES AND PERTURBATION THEORY FOR HAMILTONIAN SYSTEMS

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 4 Aug 80, after abridgment 20 May 81)  
pp 218-226

NEYSHTADT, A. I., All-Union Scientific Research Institute of Medical  
Instruments

[Abstract] Propagation of beams through smoothly irregular plane waveguides can be described by a Hamiltonian which is a function of the longitudinal coordinate, this space coordinate being equivalent here to the time coordinate. Such a Hamiltonian can be integrated approximately by application of the perturbation theory in action-angle variables. This method is much simpler than asymptotic methods and the same for both refractive waveguides and waveguides with reflecting walls. The first step in solving the problem in the case of a waveguide with a curvilinear axis is transformation of  $p, q$  variables ( $p$ - momentum,  $q$ - length of normal to axis) to  $I, \varphi$  variables ( $\varphi$ - angular coordinate along unperturbed trajectory,  $I$ -  $1/2\pi$  times area under unperturbed trajectory through point  $p, q$ ). The next step is asymptotic integration after another canonical near-identity transformation from  $I, \varphi$  variables to  $J, \psi$  variables by means of a later determined generating function. The procedure and calculations are demonstrated on propagation through a smooth transition between two regular waveguides. The procedure is extended to configuration of beams with swinging of action behind a transition of finite smoothness and behind an infinitely long transition with analytical profile. The author thanks V. I. Arnol'd for proposing the topic and V. A. Borovikov for his discussion and suggestions. Figures 3; references: 17 Russian.  
[201-2415]

## DOUBLE-RESONANT WAVEGUIDE IRIS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 26, No 8, Aug 81  
(manuscript received 19 May 80, after revision 13 Jan 81) pp 1605-1613

ALYBIN, V. G., GORDYUKHINA, N. M., LEBEDEV, I. V. and FRADKIN, B. M.

[Abstract] The results are presented of theoretical and experimental investigation of a new variety of multislot waveguide irises which have resonances of parallel and series types. An electrodynamic solution of the problem is given. It is shown that the calculations and experiments conducted indicate the possibility of a sufficiently correct electrodynamic description of a new variety of waveguide units--double resonant irises.

In the literature an effort is made to consider irises which have some similarity to the units described in the present paper. However, the procedure used in them is limited considerably more by the coarse scope of known concepts concerning the capacitance of the irises in a waveguide, and does not make it possible fully to consider the properties of multislot irises. The investigations conducted in the present paper develop the results of works in the literature and add to calculations based on the method of equivalent circuits. The extent of calculations based on a system containing control, lasing or amplifier microwave diodes is of interest. Figures 6; references 4: 3 Russian, 1 Western.  
[88-6415]

UDC 621.385.6

#### CONDITIONS FOR EXCITATION OF HIGHER-ORDER OSCILLATION MODES IN OROTRON

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 18 Feb 81) pp 368-373

SOLOV'YEV, A. N. and TSEYTLIN, M. B.

[Abstract] Cutoff of the fundamental oscillation mode in microwave devices such as the long-interaction orotron can occur due to higher-order oscillation modes simultaneously excited by a beam current much above the starting level. Here the conditions for excitation of these modes in an open resonator are established on the basis of the amplitude distribution of the h-f field along the interaction space. This distribution is first assumed to be arbitrary and the corresponding nonlinear equation of motion in the one-dimensional approximation is linearized. The ratios of m,n-mode to 0,0-mode starting currents and resonator energies are then calculated in terms of geometrical relations, for an open resonator with spherical mirrors. The results, fairly well supported by experimental data on  $m = 0, 1, 2$ ;  $n = 0, 1, 2$  modes, reveal that with increasing space charge, at a constant length of the interaction space, the minimum starting current increases but the ratio of m,n-mode to 0,0-mode starting currents decreases. Figures 2; references: 4 Russian.  
[199-2415]

UDC 621.382:517.944

THERMAL CONDITIONS IN SEMICONDUCTOR POWER DEVICES OPERATING IN SINGLE-PULSE MODE

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 25, No 2, Feb 82 (manuscript received 15 Jun 81) pp 81-85

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imeni N. I. Lobachevskiy

[Abstract] A mathematical model and an algorithm are constructed for determining the thermal conditions in an axisymmetric multilayer power thyristor structure with a p-n-p-n semiconductor element containing the control electrode in the silicon region, and with thermally insulated lateral surface. All heat is assumed to evolve in the n-base and dissipate either through one side (pin construction) or through both sides (disk construction). The temperature field produced by a single current pulse is calculated from the two-dimensional equation of transient heat conduction in cylindrical coordinates, for appropriate initial and boundary conditions. The temperature distribution depends on shape and location of the control electrode, it in turn determines the maximum permissible load and the cooling requirements. A close agreement is found between results of these calculations and experimental data on the maximum excess temperature as a function of time in TB-400 and TB151-50 thyristors with centrally located circular control electrode and various durations of single breakdown-current pulses. The paper was recommended by the Department (Kafedra) of Theoretical Physics. Figures 2; references: 10 Russian.  
[202-2415]

## USE OF SEMICONDUCTORS FOR CONVERSION OF SOLAR ENERGY

Yerevan PROMYSHLENNOST' ARMENII in Russian No 10, Oct 81 pp 20-22

ARUTYUNYAN, V. M., doctor of physical and mathematical sciences,  
 SARKISYAN, A. G., candidate of technical sciences, and PANOSYAN, Zh. R.,  
 candidate of physical and mathematical sciences

[Abstract] Approximately 100 solar electrical stations [SES] operate in the USSR. An experimental base in the Crimea, an industrial SES with a power of 5000 kW, will be created. In the USSR as far back as 30 years ago serious attention was paid to the sun as a source of energy. Solar equipment for heating and for boiling water, its desalting and for obtaining steam were developed. At present in the USSR installations which use solar energy are produced and widely used in the national economy. Solar water heaters find use at agricultural enterprises, sanatoriums, laundries, bathhouses, etc. "Solar homes" of various designs are constructed in Uzbekistan, Turkestan, Tajikistan and in the southern Ukraine. In Yerevan, at the Armyanskiy Heliocenter, construction is completed of installations, the parabolic mirrors of which produce a temperature in the operating space of the solar furnace which melts the most difficult to fuse materials. Solar furnace installations make it possible to synthesize super-pure materials thanks to the freedom from various substances, inevitable with other (metallurgical) methods. Soviet scientists have made a great contribution to the development of semiconductor converters of solar energy into electrical (solar batteries). Creation of effective photoconverters, which absorb and directly convert into electricity a considerable part of the energy of the solar rays falling on them, provided a real revolution in electrical engineering. Our progress in semiconductor photoconverters came in the cosmos. Wide use of semiconductor solar batteries under terrestrial conditions is retarded because of the very high cost of a kilowatt of installed power, which amounts today to tens of hundreds of thousands of rubles for a silicon battery with an efficiency of ~12% and somewhat greater for a battery of gallium arsenide-aluminum heterophoto elements with an efficiency which attains the value of ~20%. Technical progress will of course lead to a considerable reduction of the cost of solar batteries, but in the immediate future this is possible only because of a reduction of their efficiency. However, in principle this path is very promising and merits the most intent attention of researchers. One of the means of lowering the price of solar electrical energy is the use of electro-chemical methods of converting solar energy. This plan considers the possibility of converting solar energy into electro-chemical elements of the regenerative type. An energy diagram of a regenerative electrochemical element is presented and the method of its functioning is described. The simplicity of creating the required potential barrier by a simple immersion of the semiconductor electrode into an electrolyte (i.e., not requiring creation of special p-n junctions and antireflecting covers), as well as the possibility of using inexpensive polycrystalline semiconductor films, among those produced by ceramic technology, is among the advantages of liquid solar batteries. The problem of accumulation of energy can be successfully solved if the solar or electrical energy is used for direct decomposition of water into hydrogen and oxygen. Figures 1.

[157-6415]



UDC 535.247.4

OPTOELECTRONIC DIFFERENTIAL BRIGHTNESS METER

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 24, No 11, Nov 81 (manuscript received 27 Oct 80) pp 81-83

DORINA, V. N., DORIN, V. A. and D'YACHENKO, V. G., Leningrad Polytechnical  
Institute imeni M. I. Kalinin

[Abstract] An optoelectronic brightness meter is described, in which an instrument adjustment for the initial level is introduced. With the aid of this brightness meter it is possible to measure the difference in blackening of different sections of a photograph and by means of repeated measurements it is also possible to measure the contrast. At the basis of the instruments the principles are placed which were used in a device described in a 1969 paper of which V. N. Dorina (see above) was the principal author. The difference is the addition of a clipper of the electrical signal and the presence of a matching pair of light-emitting diodes--phototransistors. The read-out spot has an area less than  $1 \text{ mm}^2$ . The paper was recommended by the Department (Kafedra) of Experimental Physics. Figures 3; references: 2 Russian.  
[151-6415]

UDC 535.853.6.001.2

EFFECT OF RANDOM ERRORS ON CHARACTERISTICS OF ACOUSTO-OPTICAL  
CORRELATORS OPERATING IN REAL TIME

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 25,  
No 2, Feb 82 (manuscript received 8 Oct 80, after abridgment 3 Aug 81)  
pp 204-210

VODOVATOV, I. A. and ROGOV, S. A., Leningrad Polytechnic Institute

[Abstract] An optical correlator at the output of an acousto-optical modulator is considered for processing harmonic signals in real time, with a space filter in the frequency plane which has been produced holographically

from a multichannel reference transparency. The performance of such a correlator in the first diffraction order is analyzed taking into account field fluctuations at the system output due to several independent random effects. Results of calculations for two special cases, a random quantity with a uniform distribution and with a normal distribution respectively, indicate that the mean field at the output is determined by phase errors and by variances of modulator and transparency design parameters, while the dispersion of the field is determined principally and in the same manner by phase and amplitude errors. Figures 3; tables 1; references 8: 7 Russian, 1 Western.  
[201-2415]

UDC 535.854

#### ELIMINATION OF AMBIGUOUS READOUT OF INTERFERENCE GONIOMETERS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 24, No 11, Nov 81 (manuscript received 29 Aug 79) pp 77-80

KHOROSHEV, M. V., Moscow Institute of Engineers of Geodesy, Aerial  
Photography and Cartography

[Abstract] The effect is shown of readout ambiguity on the construction of interference-type measuring devices. Characteristic special features of the process of measurement by interference devices are listed. All these are connected with a solution of the problem of ambiguous readout. A scheme for a two-channel device is proposed which makes it possible to eliminate the ambiguity of readout and to expand the range of magnitudes measured by interference goniometers. A device realized in a number of modifications at the Department (Kafedra) of Optoelectronic Devices of the Moscow Institute of Engineers of Geodesy, Aerial Photography and Cartography makes it possible to perform angular measurements with an error above  $0''.1$  in the range to  $5'$ . The paper was recommended by the Department of Optoelectronic Devices.  
[151-6415]

## ALGORITHM OF SYNTHESIS ON COMPUTER OF DOUBLE-CEMENTED OBJECT

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 24, No 11, Nov 81 (manuscript received 25 Aug 79) pp 73-76

SHEKHONIN, A. A. and RODIONOV, S. A., Leningrad Institute of Precision  
Mechanics and Optics

[Abstract] A cemented two-lens objective is one of the most widely distributed and studied forms of optical systems and consequently its automated calculation is a necessary component in the synthesis of an automatized system for designing optics. The present work considers the problem of developing an automatized synthesis of a cemented doublet with optimum balancing of all the aberrations in any spectral region with allowance made for the final magnitude of the visual field and under the condition of a choice of the best combination of glasses. A chart is shown of the algorithm of automated synthesis. The results of a calculation of cemented two-lens objectives on the YeS-1022 computer, using the algorithm, are given in a table where three versions of the synthesis of optimum construction are presented. The paper was recommended by the Department (Kafedra) of Optical Devices. References: 5 Russian.  
[151-6415]

## STABILITY OF EMISSION PULSES IN LASER WITH PERIODIC LOSS MODULATION

Kiev IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 25, No 2, Feb 82 (manuscript received 19 Mar 80, after completion 1 Dec 80)  
pp 157-168

DAUME, E. Ya., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] Unidirectional emission of pulse sequences in a traveling-wave laser with a two-level active medium having a uniformly widened amplification line and with periodic modulation of losses in the resonator cavity is analyzed for stability. The emission pulses are assumed to be identical and to have a quasi-Gaussian form negligibly affected by saturation and by changes in the population difference but significantly affected by gain dispersion. The modulator is a lumped element which varies the jump of amplitude of the electric field intensity at its location, this action being equivalent to multiplication of the input signal by some periodic function of time. The equations for the electric field of a linearly polarized plane wave, for the polarization of the active medium, and for the population difference in the laser are solved in dimensionless coordinates for a single circulation inside the resonator cavity. An analysis of the

quasi-periodic solution for the steady state reveals that a pulse formed during a modulator transmission peak will be stable, while pulses leading or lagging the maximum will be unstable on account of departure from the Gaussian approximation in the cases of very short circulation time or very short polarization relaxation time. The author thanks V. I. Bespalov for formulating the problem and discussing the results. Figures 3; references 10: 4 Russian, 6 Western.  
[201-2415]

UDC 778.38.778.5

QUALITY OF PANORAMOGRAM PHOTOGRAPHY OF NATURAL SCENES FOR HOLOGRAPHIC CINEMATOGRAPHY

Moscow TEKHNICA KINO I TELEVIDENIYA in Russian No 12, Dec 81 pp 30-32

IGNAT'YEV, N. K., KOSODUROV, S. I. and FEDCHUK, I. U., All-Union Scientific Research Motion Picture Institute

[Abstract] An analytical investigation is made of the scattering function of a line of parallax-panoramograms in a horizontal plane. The following items are considered: 1) Basic parameters of photography and reproduction; 2) Scattering function of line; and 3) Transverse resolution and depth of space reproduced. The following are presented in figures: 1) Equivalent optical circuit of a parallax-panoramogram and the optical circuit of a system of raster-carrier of photoeffect; 2) Determination of the transverse resolution of a light line; 3) Curve of change of width of scattering function of line; and 4) Example of curve of transverse resolution of parallax-panoramogram. It is shown that: 1) The scattering function of the line of a parallax-panoramogram is determined on the basis of a consideration of the optical circuit for formation of an image behind the lens of the raster and the scheme of its observation by the eye; 2) The characteristics are obtained of the transverse resolution of a parallax-panoramogram as a function of the depth of the image being reproduced. As an example, the characteristics are sufficiently close to the actual; and 3) The characteristics of the resolution are asymmetrical with reference to the plane of the raster and are more restricted from the side of the observer. Figures 4; references: 2 Russian.  
[159-6415]

UDC 535.215.5

PULSE PHOTOELECTRIC CURRENT IN ORGANIC SEMICONDUCTOR LAYERS QUASI-HOMOGENEOUS WITH RESPECT TO THICKNESS OF CARRIER GENERATION

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 29 Jun 81) pp 3-9

GAYLIS, A. K. and KOLESNIKOV, V. A., Physics and Power Engineering Institute,  
LaSSR Academy of Sciences

[Abstract] An analysis is made of a photoelectric pulse current as a function of the intensity of the exciting light. The following points are considered: 1) Effect of level of generation of charge carriers on pulse photoelectric current; 2) Pulse photoelectric current with inhomogeneity of carrier generation with respect to thickness of specimen; and 3) Discussion of experimental results. The dependence of the pulse photoelectric current in oriented layers of pentacene  $L = 1.75$  micrometer thick on the intensity of the incident light was measured. The area of the specimen was  $10 \text{ mm}^2$ . A LTIPCh-5 laser with a modulated Q and a wavelength  $\lambda = 0.53$  micrometer served as the source of radiation. Measurements were made at room temperature in a nitrogen atmosphere. The intensity of the incident radiation was varied by neutral filters. The measurement were made a number of voltages on the specimens from 1 to 10 V. The authors thank E. A. Silin'sh for valuable council during discussions. Figures 3; references 9: 7 Russian, 2 Western (1 in translation).  
[177-6415]

## LIMITING CHARACTERISTICS OF GaAs INTEGRATED CIRCUITS WITH FIELD-EFFECT TRANSISTORS

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 5 Mar 81) pp 95-103

STAROSEL'SKIY, V. I. and SAPEL'NIKOV, A. N., Moscow Institute of Electronic Engineering

[Abstract] Field-effect transistors with Schottky gate or heterojunction are considered for logic circuits, normally-closed devices having excellent energy characteristics but requiring very thin (0.1 micrometer) highly homogeneous GaAs layers and normally-open devices offering a higher response speed with thicker (0.2  $\mu\text{m}$ ) GaAs layers. Further improvement in both energy and speed characteristics requires a technology which takes into account the fact that charge accumulation in the subgate region decreases with decreasing gate length, that ohmic resistance of contacts and in passive source and drain regions decreases the slope of the current-voltage characteristic while increasing the residual voltage and the power drain, and that the gate-channel capacitance is proportional to the linear dimensions of elements squared. A comparative evaluation of the main parameters, based on piecewise-linear approximation of the current-voltage characteristic and on model topology of the respective structures, indicates that normally-open field-effect transistors with Schottky gate are preferable on account of their highest operating speed. Normally-closed devices should be considered only when a technology for producing sufficiently short gates (0.2-0.5 micrometer) is available or where the energy requirements are overriding. Parasitic resistance can be minimized by additional doping of contact regions and by fabrication of gates by method of self-matching. Figures 8; references 10: 1 Russian, 9 Western.  
[250-2415]

UDC 535.42:534.321.9

THEORY OF LIGHT DIFFRACTION BY ULTRASOUND WAVE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 13 Oct 80) pp 241-247

ZIL'BERMAN, G. Ye., SIDOROV, I. N. and KUPCHENKO, L. F.

[Abstract] The theory of light diffraction by a moving grating formed by a sound wave propagating through an isotropic homogeneous medium involves solution of the appropriate Raman-Nath equations for a wide range of interaction angles. These equations of light diffraction by ultrasound waves follow from the wave equation for the electric field of a light wave. Most important are the solutions to these equations for integral values of the parameter  $z = \sin\theta/\sin\theta_B$  ( $\theta$ - interaction angle,  $\theta_B$ - Bragg angle). The solutions for an even  $z$  can be reduced to the  $z = 0$  case and the solutions for an odd  $z$  can be reduced to the  $z = 1$  case. An examination of these solutions and their properties reveals higher-order Bragg reflections. Experimental detection of second-order, third-order, and higher-order Bragg reflections requires determining the widths of the corresponding resonance curves, i.e., of the successively narrower intervals of interaction angle within which the corresponding diffraction components are sufficiently strong. The critical angle in each case must then be approached within a successively narrower tolerance. Figures 1; references 10: 6 Russian, 4 Western.  
[199-2415]

## INTEGRATED ACOUSTO-OPTICAL CELL WITH THIN-FILM PRISM FOR SURFACE ACOUSTIC WAVES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 2, Mar-Apr 82  
(manuscript received 3 Nov 81) pp 177-179

AKSENOV, Ye. T., KOZLOV, K. V., KUKHAREV, A. V., LIPOVSKIY, A. A.,  
PAVLENKO, A. V. and SANIN, K. V., Leningrad Polytechnical Institute  
imeni M. I. Kalinin

[Abstract] Thin metal films on piezoelectric substrates can serve as simple devices for controlling the phase and the direction of propagation of surface acoustic waves excited in a pair of acousto-optical cells. The feasibility of using a thin-film prism on one of two integrated cells is established in an experimental study. A pair of piezoelectric transducer cells with center frequencies 165, 220 MHz and apertures 2.2, 1.7 mm, respectively, each of interdigital construction, are tested with a GaP prism (0.17 mm x 2.21 mm, angle  $4.34^\circ$ ) before the 165 MHz cell. The device was built by the photolithographic process, with a 100 nm thick aluminum film on a Y-cut  $\text{LiNbO}_3$  crystal substrate in which an optical waveguide had been formed by diffusion from a 40 nm thick titanium film in air. Subsequent measurements with the  $\text{TE}_0$ - $\text{TE}_0$  mode of  $\lambda = 0.63 \mu\text{m}$  light constant 8 V voltage amplitude reveal a 100 MHz wide band of opto-acoustic diffraction without adjustment of the angle of incidence of light, with the maximum efficiency (amplitude) of 92% at 235 MHz and 400 mW input power, in contrast to the sharp resonance peaks at respective center frequencies when the two cells are excited separately. Figures 2; references 6: 3 Russian, 3 Western.  
[250-2415]



NEW ACTIVITIES, MISCELLANEOUS

UDC 537.11

QUASI-UNIDIMENSIONAL ORGANIC METALS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 3 Jul 81) pp 78-89

LAUKHIN, V. N. and SHCHEGOLEV, I. F., Institute of Chemical Physics,  
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[Abstract] A survey is made of the physical properties of high-conducting quasi-unidimensional organic metals. All the organic metals known at present may, perhaps, be divided into three groups, two of which are considered in some detail in the present paper. Problems of stabilization of the metallic state at low temperatures are discussed. The authors thank E. B. Yagubskiy for much assistance during preparation of the materials for the work. Figures 7; tables 2; references 40: 16 Russian, 24 Western. [177-6415]

UDC 537.312.62.029.6

CALCULATION OF QUASI-PERIODIC PROCESSES IN NONAUTONOMOUS JOSEPHSON JUNCTION

Moscow RADIOTEKNIKA I ELEKTRONIKA in Russian Vol 27, No 2, Feb 82  
(manuscript received 8 Aug 80) pp 363-367

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[Abstract] The response of a Josephson junction to a weak quasi-harmonic signal is calculated on the basis of the resistive low-capacitance model of a superconducting point contact. A general expression for the low-frequency slow voltage component across a nonautonomous Josephson junction is derived by the method of averaging with quasi-linearization, through reduction of the model equation to standard form by a change of variables. Results obtained by this method are more accurate than those by the method of small perturbations and by the Poincare method, they are also applicable not only in the resonance band but also far away from it and in the

transition range of beats. The authors thank V. V. Migulin, V. B. Braginskiy and I. I. Minakova for helpful discussions and comments. References:  
8 Russian.  
[199-2415]

UDC 537.312.62:621.3.029.6

#### EFFECT OF BACKGROUND RADIATION ON JOSEPHSON DETECTOR CHARACTERISTICS

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(manuscript received 6 Mar 80) pp 1760-1764

IL'IN, V. A., SHURMINOVA, T. M. and ETKIN, V. S.

[Abstract] An experimental investigation is made of the effect of background radiation on the characteristics of a Josephson detector and the radiometer with such a detector in a wide band  $T_f$ , which corresponds to the conditions of real radio astronomical reception on Earth and in cosmic space. A block diagram is presented of a unit used for study of the sensitivity of detectors, and the technique of the experiment is explained. The authors conclude that the sensitivity of Josephson detectors and the radiometers on their basis significantly depends on the noise temperature coming into contact with background radiation. The reduction of it in magnitude as compared with the contact temperature significantly improves the sensitivity of the detector. Use of a matched load cooled to  $T = 4.2$  K makes it possible to investigate a superconducting point contact [SPC] under conditions of real radio astronomy reception on Earth ( $T_f \sim 60$  K) and in cosmic space ( $T_f \sim 10$  K). In order to obtain a further increase of the sensitivity of the detectors based on Josephson SPC, an improvement of the matched contact with the supply channel and expansion of the detector band is necessary as well as a decrease of the noise of the low-frequency part of the radiometer. The authors thank Ye. M. Gershenzon, V. P. Zavaleyev, L. S. Kuz'min and K. K. Likharev for fruitful discussions. Figures 4; references 9: 8 Russian, 1 Western.  
[88-6415]

## SOME PROBLEMS IN CONTEMPORARY THEORY OF LOW-DIMENSIONAL ORGANIC METALS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I  
TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 13 May 81) pp 55-62

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[Abstract] The present work is concerned with organic complexes with charge transfer, synthesized in recent years. Such complexes are molecular crystals which consist of the plane molecules of acceptors (A) and donors (D). The characteristic special feature of such systems is the pronounced anisotropy of their properties, the reason for which involves the distinctive stack packing of the molecules in these crystals. At the same time conductivity in directions perpendicular to the stacks, by virtue of which these crystals are essentially quasi-one dimensional. In the structure the relation of the complexes mentioned can be divided into two classes. Crystals which consist of displaced stacks in which A and D alternate pertain to Class I; Class II consists of separate alternating stacks of A and D. Typical representations of Class I are complexes of TTF-chloranil and others; of Class II--TTF TCNQ, NMP-TONQ, complexes of platinum of mixed valence  $K_2Pt(CH)_4Br_{0.3} \cdot 3H_2O$  and others. The highly-conducting systems--organic metals pertain as a rule to Class II; systems of Class I are typical semiconductors with a relatively low magnitude of conductivity. Other problems in contemporary theory of low-dimensional organic metals are also discussed. The electronic structure for a number of charge carrier complexes are studied and their correlation functions calculated. Figures 3; references 23: 11 Russian, 12 Western.  
[177-6415]

## ANOMALOUS GROWTH OF OXIDE ON SILICON AT LOW OXYGEN PRESSURES

Moscow MIKROELEKTRONIKA in Russian Vol 11, No 1, Jan-Feb 82  
(manuscript received 10 Oct 80) pp 40-44

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[Abstract] The results are given of a study of the reproducible production of hyperfine oxide films on a silicon surface. With sufficiently low oxygen pressures and sufficiently high temperatures the process of the oxidation of silicon is replaced by etching of the silicon. A study is made here of oxidation in the critical region adjoining the etching region. The

experiment was conducted in a vacuum chamber making it possible to achieve pressure of below  $10^{-9}$  mm Hg. The silicon specimen was heated by passing current directly through it and the surface was cleaned by repeated oxidation and annealing to the oxide's vaporization temperature, after which the specimen was cooled, oxygen was let into the chamber to a specific pressure and the temperature of the specimen was raised to the chosen amount and exposure to the oxygen took place for a few minutes. The amount of oxide grown during exposure was determined by a mass spectrometer or by the scintillation method or with an ellipsometer. Volt-farad characteristics and conduction with a variable signal were measured after applying gold contacts 100 microns in diameter. These measurements made it possible to monitor the charge state of the silicon-oxide interface and the dielectric properties of the oxide. The results demonstrate that when the temperature rises above a certain critical value anomalies originate both in the kinetics of growth and vaporization and in the properties of the oxide and interface. A transition region of the growth of an anomalous oxide occurs between the regions of the growth of a normal oxide and of etching of the silicon surface by the oxygen, and this transition region occurs at temperatures of 900 to 1100 °C with a drop in the oxygen pressure below the critical value of  $10^{-4}$  and 0.5 mm Hg, respectively. The anomalous oxide consists of two phases, the first of which vaporizes easily at temperatures above 1000 °C and the second of which does not vaporize even at 1200 °C. The anomalous oxide film differs in composition from  $\text{SiO}_2$  and its dielectric constant can vary from 4 to 6. There is an increase in porosity of the oxide, the rate of surface generation, the depth of the spatial distribution of traps in the surface layer of the oxide and in the positive embedded charge in the oxide. A sufficiently high oxygen pressure must be maintained in order to suppress the process of the growth of an anomalous oxide. Figures 2; references 14: 5 Russian, 9 Western.  
[210-8831]

UDC 541.572:541.65

PROBLEMS OF SEARCH FOR STRONG ORGANIC ELECTRON DEVICES AND ELECTRON ACCEPTORS AND THEIR PHYSICO-CHEMICAL PROPERTIES

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I TEKHNICHESKIKH NAUK in Russian No 6, Nov-Dec 81  
(manuscript received 3 Jul 81) pp 63-77

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[Abstract] Using generalized data from the literature, a number of organic compounds are considered with respect to their individual classes and their individual classes and their ionization potential [IP] or electron affinities [EA], with an indication of the shortcomings of these compounds as strong donors or acceptors, and on possible means of search. Possible ways for their synthesis are considered. The structural formulas of organic compounds are presented. Under the formulas the number of the formula and the IP or

EA are given in e.V. In the opinion of the authors, during a search for new donors and acceptors it is necessary to focus on a solution of the following problems: 1) Use of quantum-chemical calculations of ion radicals for the characteristics of delocalization of an unpaired electron in front orbits with the object of revealing the effect of change of the chemical structure; 2) Synthesis of new neutral donors with an IP of 6.2-7.0 eV, varying structure and symmetry, and search for donors in the unknown region  $IP < 6.1-6.2$  e.V., forming cation radicals resistant to chemical action and dimerization; 3) Synthesis of anionic donors with  $IP < 2.2-2.5$  eV., forming stable radicals; 4) Synthesis of new neutral acceptors with an EA of 2.0-3.2 e.V., a varying structure and symmetry, search for new "superstrong" acceptors with  $EA < 3.2$  e.V., forming stable anionic-radicals; and 5) Synthesis of conjugated cations with  $EA > 6.2$  E.v., forming stable radicals. The author thanks V. E. Kampar for fertile discussions and for assigning the data of quantum-chemical calculations. Figures 4; tables 1; references 42: 28 Russian, 14 Western.  
[177-6415]

CSO: 1860

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